ANL/EES-TM-220

Environmental Control Technology Survey of Selected U.S. Strip Mining Sites

Water Quality Impacts and Overburden Chemistry of Southern Illinois Study Site IL-1

ANL EES

ARGONNE NATIONAL LABORATORY
Energy and Environmental Systems Division

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This informal report presents preliminary results of ongoing work or work that is more limited in scope and depth than that described in formal reports issued by the Energy and Environmental Systems Division.

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ARGONNE NATIONAL LABORATORY
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ENVIRONMENTAL CONTROL TECHNOLOGY SURVEY OF SELECTED U.S. STRIP MINING SITES

Water Quality Impacts and Overburden Chemistry of Southern Illinois Study Site IL-1

by

William C. Hood
Southern Illinois University

for

Argonne National Laboratory
Energy and Environmental Systems Division
Environmental Control Technology Program

under Contract No. 31-109-38-3406

December 1982

work sponsored by

U.S. DEPARTMENT OF ENERGY
Division of Environmental Control Technology

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FOREWORD

The Argonne National Laboratory (ANL) program entitled "Environmental Control Technology Survey of Selected U.S. Strip Mining Sites" is being funded by the U.S. Department of Energy (DOE). The program was established in 1975 by an interagency agreement between DOE's precursor -- the U.S. Energy Research and Development Administration -- and the U.S. Environmental Protection Agency (EPA).

This program has a twofold purpose which is related in part to the interests of its two federal sponsors. The overall issue addressed by both sponsors is the need to satisfy increased coal demand in an environmentally acceptable manner. Each sponsor, however, has particular interests: DOE is interested in the efficacy and practicability of coal mine effluent control options currently in use, an identification of control technology problems and needs, and recommendations for research in these areas; the EPA was interested in an assessment of the validity of its effluent limitations guidelines and new source performance standards for the coal mining industry, with this assessment emphasizing seasonal and climatic variation impacts on effluent quantity and quality. A program plan was outlined to (1) project future coal production levels to the year 2000 as a basis for selection of case study mines, (2) gather data on effluent volumes and characteristics at surface mine case study mines, (3) examine the efficacy and economics of current effluent-control systems (treatment facilities and settling ponds), (4) assess the validity of the effluent guidelines, and (5) evaluate potential environmental impacts related to increased surface mining.

Summaries of the program's various aspects are being published in several volumes. Water quality data gathered at the case-study sites are analyzed in terms of potential local impacts in Argonne report ANL/EMR-2, Volumes 2A-2C, and in several reports in the ANL/EES-TM- series. This report (included in the latter series) is being published essentially as received (i.e., with only minimal revision) from the author-consultant named on the title page. All sites were coded using state abbreviations in order to protect the identity of individual mines. In ANL/EMR-2, Volume 3, the efficacy and economics of the various types of control technologies are examined, along with physical and chemical characteristics of treatment waste products. Report ANL/EMR-2, Volume 4, contains an assessment of the EPA effluent limitations guidelines (and those of the U.S. Dept. of Interior's Office of Surface Mining) for the coal mining industry relative to the data collected under this program. Thus, this entire set of reports examines the efficacy of various control technology options and assesses the potential environmental impacts related to increased surface mining based on detailed case-study site data.

INTRODUCTION

The Argonne National Laboratory (ANL) program entitled "Environmental Control Technology Survey of Selected U.S. Strip Mining Sites" is being funded by the U.S. Department of Energy (DOE). The program was initiated in 1975 by an interagency agreement between DOE's predecessor -- the U.S. Energy Research and Development Administration -- and the U.S. Environmental Protection Agency (EPA).

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ENVIRONMENTAL CONTROL TECHNOLOGY SURVEY OF SELECTED U.S. STRIP MINING SITES

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William C. Hood

ABSTRACT

As part of a program to examine the ability of existing control technologies to meet proposed federal guidelines for the quality of aqueous effluents from coal mines, intensive studies of water, coal, and overburden chemistry were conducted at a surface mine in southern Illinois during 1976-1977. Sampling locations included the receiving stream (which flows partly in a man-made channel through the minesite), drainage from old and new settling ponds, drainage from an old spoil area, and intake water and slurry for the coal cleaning operation. No chemical treatment of mine effluent was practiced at this site. In general, mine effluent complied with federal and state standards for pH, manganese, and iron. However, total suspended solids concentrations often exceeded permitted maximum values in the effluent and the receiving stream due to the use of relatively small settling ponds (low retention time) and sediment contributions from erosion of unlined banks along the diversion channel for the receiving stream. Accompanying overburden sampling and analysis completed for this project indicated a positive value for the net neutralization potential.

1 INTRODUCTION

The southern Illinois coal-producing area is a portion of the Eastern Region of the Interior Coal Province (Figure 1). Along the outcrop area of Pennsylvanian-age rocks stretching across the southern third of the state are some of the more important counties in terms of coal production. Perry, Williamson, and Saline Counties have all produced more than 225 million tons of coal since 1882, with much of the production coming from surface mining. This study focuses on a surface mine in this three-county area that is fairly representative of mines in the western part of the southern Illinois coal-producing area.

1.1 SELECTION OF THE SITE

This mine was suggested as a study area by Dr. Donald Johnson of Argonne National Laboratory. A prime consideration in the selection was the mine's location in the western part of the southern Illinois producing area.

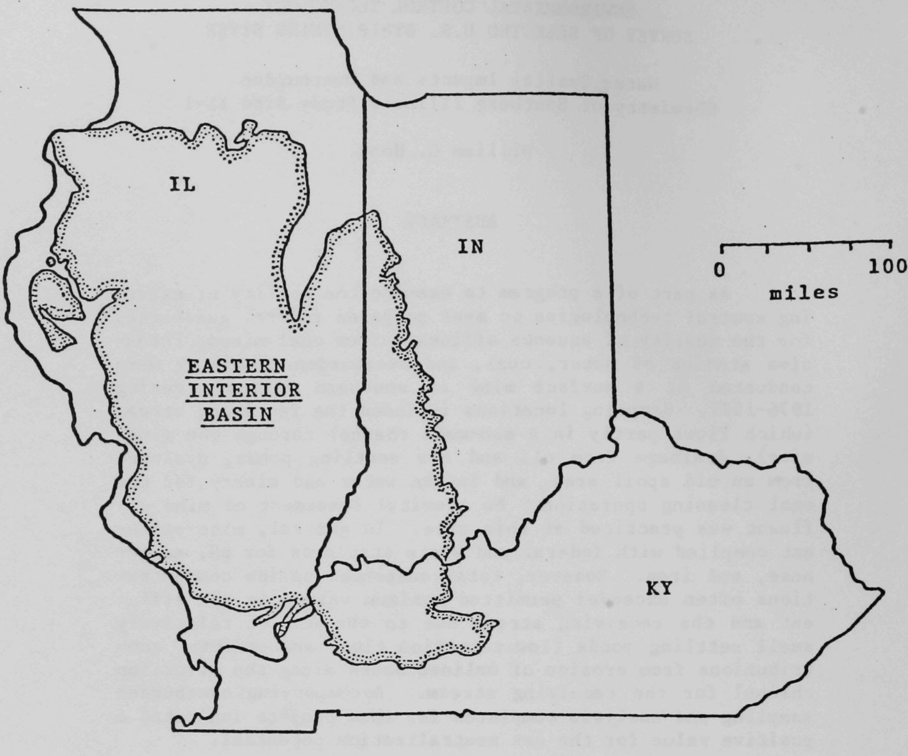


Fig. 1 Eastern Interior Basin in Illinois, Indiana, and Kentucky

Sampling began on June 8, 1976, and continued until July 5, 1977. Sampling was done every other week, with few exceptions. The only major break came during January of 1977 when severe cold weather froze the streams in the area and made sampling impractical.

The mine under study has been designated as Mine IL-1. It is located in the Illinois Coal Field and specifically in the Southwestern Producing District (Keystone Coal Manual designation).

Drainage of the mine area is into a tributary of the Big Muddy River. The Big Muddy is a tributary of the Ohio River.

1.2 PHYSIOGRAPHY AND TOPOGRAPHY

Mine IL-1 is in the Mount Vernon Hill County natural region, which lies within the Central Lowlands physiographic province and specifically is located in the southern portion of the Southern Till Plain Division. The Mount Vernon Hill County is an area of mature topography, with restricted, flat-to-gentle rolling uplands and prairies and broad alluvial valleys along larger streams (Leighton et al., 1948). Wooded hilly areas and low cliffs are present. The bedrock is dominantly shale accompanied by some thin, resistant sandstone layers that tend to form ridges. A thin mantle of loess and Illinois age drift, which only slightly affects the topography, conforms to the bedrock surface. Glacial landforms are absent. The area is one of low relief, with the maximum difference in elevation between the highest and lowest elevations within a typical 7.5-minute topographic quadrangle being on the order of 100 to 200 feet. The area has a completely developed drainage system characterized by streams that have broad terraced valleys and low gradients. Drainage is good in the uplands, but larger valley bottoms are poorly drained and are subject to frequent flooding (Leighton et al., 1948).

Many of the larger stream valleys and some of the smaller ones are filled with unconsolidated lacustrine sediments deposited in backwater lakes. These lakes were created about 20,000 years ago when meltwater from retreating glaciers caused aggradation of the master streams bordering the region (i.e., the Mississippi, Ohio, and Wabash). Sediments built up the main valley floors above the level of the local streams and caused ponding of waters in the local drainage basins. The lacustrine sediments deposited on the floors of these lakes now form broad, flat, poorly drained valley bottoms. Many have been terraced by subsequent downcutting of the local rivers. Where encountered in mining operations, these unconsolidated water-laden sediments cause many problems.

The study mine is located in an area that has an overall elevation of about 475 feet above mean sea level. The topography of the mine area is relatively flat with most of the relief arising because of the dissection of the uplands by a small stream that is generally incised to a depth of twenty to thirty feet below the uplands. Relief on the upland plain is also about this same magnitude, making total relief in the area not more than fifty feet. Slopes on the side of the valley do not exceed five percent, whereas slopes on the upland surface are generally much less than this.

1.3 CLIMATE

The climate of the southern Illinois region is typically continental. It has cold winters and warm summers, both characterized by frequent fluctuations of temperature, cloud cover, etc. Because no natural barriers intervene, the area encounters the full sweep of winds bringing in weather typical of other areas. Southerly and southwesterly winds bring warm, showery weather up from the Gulf of Mexico whereas northwesterly winds bring cool, drier weather. Weather fronts generally pass eastward or northeastward through the area (Denmark, 1974).

Precipitation tends to be widespread over the region during fall, winter, and spring; however, summer rainfall typically occurs as localized showers which may be of high intensity. Only three or four days of snowfall exceeding one inch will occur in a typical winter, and the ground is covered with an inch or more of snowfall less than 15 days per year.

The accompanying graph shows the seasonal distribution of temperatures and precipitation at a weather station several miles from the mine site. Mean monthly temperatures range from about 35°F in January to about 80°F in July. Mean annual temperature is 58°F. Monthly precipitation is fairly uniform, varying from a low 2.4 inches in December to 4.4 inches in May (Figure 2). Spring tends to be the wettest season, with a decreasing precipitation trend occurring throughout the rest of the year. Annual precipitation averages 39.9 inches.

Precipitation at the weather station during the study period is given in Table 1 and shown diagrammatically in Figure 3. July 1977 precipitation figures are from a rain gauge at the mine.

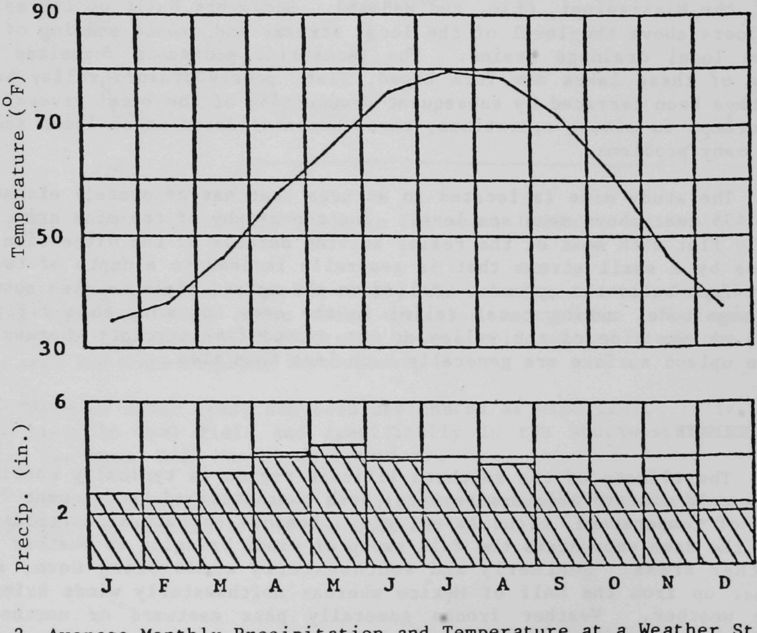


Fig. 2 Average Monthly Precipitation and Temperature at a Weather Station near Mine IL-1 (Based on data in Denmark, 1974)

Table 1 Precipitation Data for a Weather Station near Mine IL-1

	1976									1977						
Day	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1			0.03									0.18				0.24
2		0.03		0.18									0.67			
3			0.13	0.47								0.66		0.02		
4	0.05		0.14							0.10		0.04	0.07			
5			0.24				0.50			0.01						
6		0.05			0.36		1.07		0.58	0.14				0.33		
7									0.04					0.36		
8				0.20		0.02										
9				0.07		2.01				0.33					0.04	0.48
10									0.01	0.05						
11	0.01											0.63				0.07
12											0.24	1.55				1.51
13		0.22			0.10					0.24					0.16	
14		0.13			0.37					0.07						
15		0.05			0.17					0.01						
16				0.11												
17		0.06										0.03				
18			0.28									0.40				
19	0.69						0.28			0.09	0.08	0.01	0.20		0.17	
20	0.32					0.29	0.10									
21	0.07											0.03	0.19			
22												0.06	0.01		1.66	
23			0.19		0.10		1.28	0.02		0.24	0.81		0.01	1.03	0.62	
24	0.04		0.28				0.20			0.02	0.56				0.81	
25	0.15													0.35	0.33	3.44
26						0.09		0.43			0.83			0.05	0.28	0.10
27	0.02	0.02		1.45	0.22	0.31		0.17			0.03	1.11			0.01	
28	0.12	1.12										3.06	0.03		0.13	
29			0.20	0.52					0.12							
30		1.83				0.01	0.89								0.27	
31		0.70		1.78			0.01							1.03		

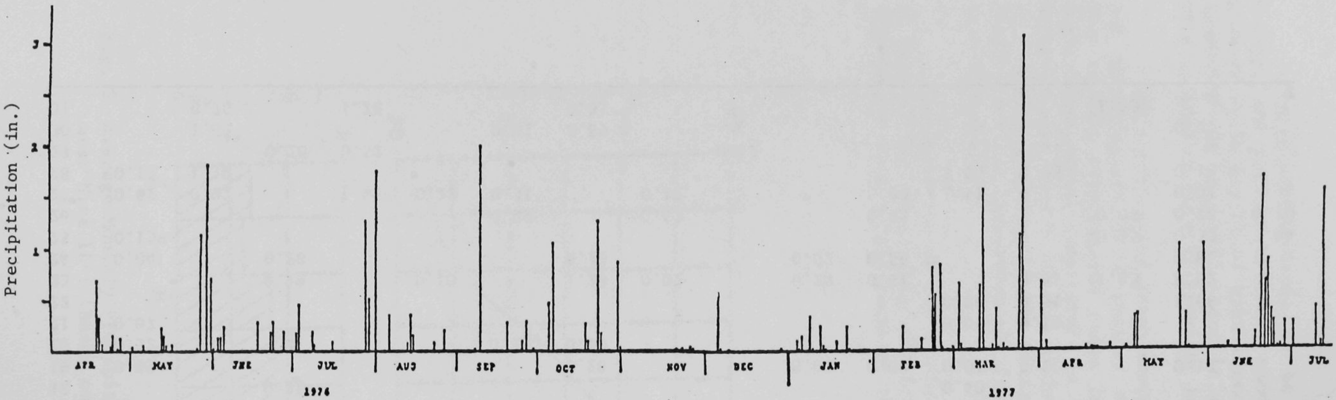


Fig. 3 Daily Precipitation at a Weather Station near Mine IL-1

1.4 GENERAL GEOLOGY

Mine IL-1 is located near the southwestern edge of the Illinois Basin, a major subdivision of the Eastern Interior Coal Basin (Figure 1). The deepest part of this basin is located close to the point where Illinois, Indiana, and Kentucky join, but the geographic center is located northwest of this point. In general, rocks along the southern edge of the basin tend to dip northward to northeastward toward the center of the basin. In the mine area the dip is about one degree toward the northeast. This results in a stratigraphic sequence of successively younger rocks going from southwest to northeast in the area.

Several large fault zones disturb this simple picture in southern Illinois; however, with one exception, faults do not appreciably disturb the Pennsylvanian rocks in the coal-producing counties. The one exception is the Shawneetown Rough Creek fault zone located in Gallatin and southeastern Saline counties. The fault itself is a high-angle reverse fault (Ross, 1963), and displacement may reach 3600 feet (Wilson, 1959).

Two other major structural features disrupt the coal-bearing rocks in the producing areas and merit description. These are the Eagle Valley Syncline and the DuQuoin Monocline.

The westward-trending Eagle Valley Syncline (also called Eagle Creek Syncline) is on the eastern side of Illinois, mainly in Gallatin County but also extending westward into Saline and southward into Hardin counties. Pennsylvanian-age rocks are strongly folded into a narrow syncline that reverses the usual northward dip of the rocks. On the south limb, the rocks dip less than 5 degree to the north, and on the north limb the dip is as much as 25 degrees to the south. The syncline is bounded on the north by the Shawneetown Rough Creek fault zone.

The DuQuoin Monocline is located where the eastern edges of Jackson, Perry, and Washington counties adjoin the western edges of Jefferson and Franklin counties. This east-facing, north-south trending structure drops on the eastern side by over two hundred feet. The DuQuoin Monocline strongly affects the thickness of the Pennsylvanian rocks that cross it, so it appears to have been active during Pennsylvanian time, separating a more stable western shelf area from a more rapidly subsiding basin (Fairfield basin) to the east.

The coal-bearing rocks of Illinois are Pennsylvanian in age, with most of the coal occurring in rocks of Middle Pennsylvanian age. Total thickness of the Pennsylvanian section in southern Illinois ranges from about 1500 feet in Perry, Randolph, and Jackson counties to about 2500 feet in Gallatin, Williamson, and Saline counties. Several formations are presently recognized, and cyclic sedimentation patterns are present within each of them. The formations of interest in this report are, from oldest to youngest, Caseyville, Abbott, Spoon, Carbondale, and Modesto. The Caseyville and Abbott, which contain almost no coal, and the Modesto, which is not generally present in the overburden of the strip mines, will be dealt with only briefly.

Caseyville Formation. In the western part of southern Illinois, i.e., St. Clair, Randolph, western Perry, and western Jackson counties, Caseyville rocks are either thin or absent. However, east of the DuQuoin Monocline (i.e., eastern Perry and Jackson counties and further east), Caseyville rocks can reach thicknesses of 300 to 400 feet and occasionally more than 500 feet.

The Caseyville Formation is dominated by clean, well-sorted quartz sandstones characterized by the presence of small white quartz pebbles. The sandstones, which make up more than 60% of the formation, are frequently channel-form and may attain thicknesses of over 100 feet. Cross-bedding is common in the channel facies. The sandstones, especially the thick channel facies, are resistant to erosion and form the prominent hills and cliffs of the Pennsylvanian escarpment in southern Illinois. The remaining portion of the formation consists of siltstone and silty and sandy shale. Limestone is virtually absent, and the rare coals are thin, lenticular, and discontinuous (Figure 4).

Abbott Formation. The Abbott Formation reaches a maximum thickness of about 350 feet in southeastern Illinois. It thins westward to about 50 feet west of the DuQuoin Monocline and eventually nearly thins out in the western part of the study area.

Lithologically, the Abbott Formation is similar to the Caseyville below it, with about half of the formation consisting of sandstone and half of shale (Figure 4). The sandstones are generally thinner, less well sorted, finer grained, and more micaceous than those of the Caseyville, and the small white pebbles that characterize Caseyville sandstone are absent in Abbott. Shales of the Abbott are less sandy than those of the underlying Caseyville, and limestones are nearly absent. Coals are thicker and a little more persistent than in the Caseyville, but are not generally of economic importance.

Spoon Formation. The Spoon Formation is about 350 feet thick in southeastern Illinois and, like the underlying Abbott and Caseyville formations, it thins toward the west, especially after crossing the DuQuoin Monocline, westward of which thicknesses are on the order of 100 feet.

The lithology of the Spoon Formation is somewhat different from the underlying Abbott and Caseyville formations (Figure 4). The shale contains less sand and silt than those of the underlying formations. Sandstones of the formation are not markedly different from those of the Abbott, although they tend to be be more argillaceous and micaceous. Both channel and sheet facies of sandstones are present. Limestones are thin but have appreciable lateral extent. They make up only a small amount (1 to 2%) of the formation.

Coals of the Spoon Formation are the earliest widespread coals of Pennsylvanian age in southern Illinois. Coals of economic importance are listed below.

- New Burnside Coal Member. This coal is well developed, but outcrops are scattered. It attains thicknesses up to five feet.

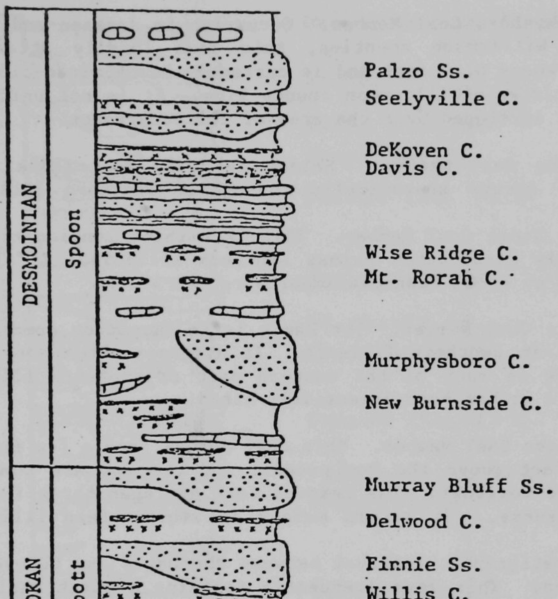


Fig. 4 Generalized Stratigraphic Column of Caseyville, Abbott, and Spoon Formations (after Hopkins and Simon, 1970)

- Murphysboro Coal Member. Occurring in Jackson and Western Williamson counties, this coal locally attains a thickness of 7 feet and is currently being mined close to the Jackson-Williamson county line. It is not uniformly well developed over the area of its occurrence.

- DeLong Coal Member. Seldom over two feet thick, this coal occurs sporadically throughout southern Illinois.

- Wise Ridge Coal Member. This is a thin, lenticular coal widely distributed across southern Illinois. It is too thin to be of economic importance.

- Davis Coal Member. The Davis is an important commercial coal in southern Illinois. It averages about four feet thick in much of the eastern part of southern Illinois where it has been extensively mined.

- DeKoven Coal Member. This coal occurs from a few feet to 40 feet above the Davis coal, and the two are commonly mined together. The DeKoven coal averages three feet in thickness. It occurs mainly in southeastern Illinois.

The stratigraphic interval between the Davis and DeKoven coals merits special mention. This zone frequently contains a black shale that is very pyritic. Where the pyritic shale is exposed to weathering, it produces some of the worst acid mine drainage problems in southern Illinois.

The combined thickness of the Caseyville, Abbott, and Spoon formations reflects and amplifies the westward thinning trend discussed under each individual formation. This portion of the Pennsylvanian has a maximum thickness exceeding 1200 feet in eastern Williamson and western Saline counties, thins westward to slightly over 200 feet in northwestern Perry County, and becomes even thinner northwest from there. The greatest change in thickness occurs in the vicinity of the DuQuoin Monocline.

Carbondale Formation. The Carbondale Formation is defined as the interval from the base of the Colchester (No. 2) Coal Member to the top of the Danville (No. 7) Coal Member (Figure 5). The thickness of the Carbondale Formation follows the same general trend as the other Pennsylvanian formations. At the inner edge of its outcrop area in Saline County, it reaches over 400 feet in thickness, and thins gradually both eastward and westward. Across the DuQuoin Monocline it thins rapidly to about 225 feet and continues the thinning trend westward until it reaches a thickness of about 175 feet along the Perry County-Randolph County border.

The Carbondale Formation consists mainly of gray shale and gray silty shale, which make up about 65% of the formation. Sandstones are locally prominent and, when in channel form, may reach thicknesses of 100 feet. Sheet-form sandstones are much thinner. The sandstones of the Carbondale Formation are commonly subgraywackes and tend to be more argillaceous than the older Pennsylvanian sandstone. Sandstones make up about 25% of the formation.

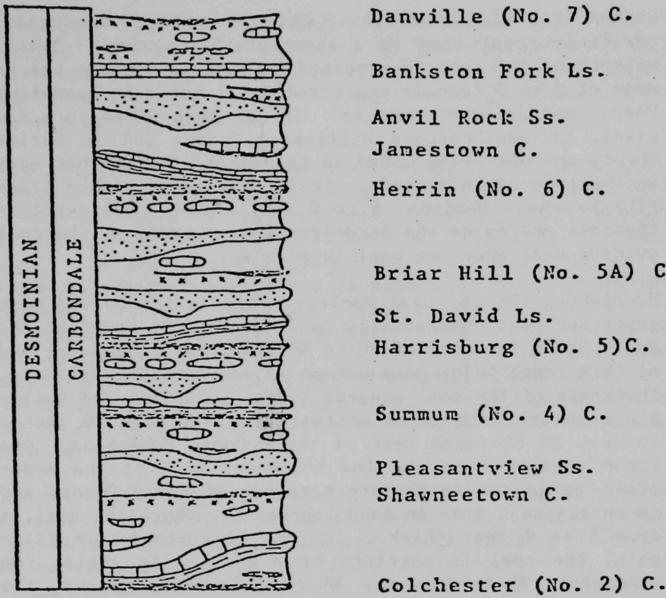


Fig. 5 Generalized Stratigraphic Column of the Carbondale Formation (after Hopkins and Simon, 1970)

Limestones are fairly common, widespread and persistent. A typical limestone is gray to dark gray, argillaceous, and contains marine fossils. The typical thickness of the limestones is one to five feet, but they occur frequently enough to make up about 5% of the formation.

Coals make up roughly 5% of the Carbondale Formation. They are abundant, widespread, and persistent. Many are relatively thick, commonly ranging from 2 to 7 feet, and occasionally reaching 15 feet, in thickness. Below is a list of the coals of the formation, in ascending stratigraphic order, beginning with the Colchester (No. 2) Coal Member at the base of the formation.

- Colchester (No. 2) Coal Member. This is a very persistent coal that locally reaches a maximum thickness of 18 inches in southern Illinois. Although it does not appear to reach minable thickness in the area, its persistence makes it useful as a stratigraphic indicator horizon.

- Shawneetown Coal Member. This was formerly called the No. 2A Coal in southeastern Illinois. It is normally quite thin but in a few scattered drill holes has been reported to reach 8 feet. Where found, it is generally about 50 feet above the No. 2, and tends to be absent in the western part of the area.

- Summun (No. 4) Coal Member. This is another widespread, persistent coal used as a stratigraphic marker. Generally thin, the coal is reported to reach a maximum thickness of 2 to 3 feet in scattered drill holes in Randolph, Perry, and Jackson counties. It has been mined in a few places in southeastern Williamson County and in Saline County and was being mined in two small pits in that area at the time of this study. It is associated with a black fissile shale horizon, 6 to 8 feet thick, that overlies the coal and makes the stratigraphic interval of the coal evident even when the coal is missing.

- Harrisburg (No. 5) Coal Member. This is the second most important coal commercially in Illinois. It overlies the No. 4 by an interval of 50 to 80 feet, with the lower end of this range being more common in southwestern Illinois. Thickness of the coal exceeds 7 feet in Saline and Gallatin counties. It thins westward to less than 30 inches in most of the area west of the DuQuoin Monocline. One known exception to the low thickness west of the monocline is in the southwestern corner of Perry County and in an adjacent area in Randolph County, where the coal is from 5 to 7 feet thick. In part of southeastern Illinois, the coal is overlain by a gray silty shale, the Dykersberg Shale Member. Where this shale occurs, the coal has lower sulfur content and more shale partings than where the more common black shale overlies the coal.

- Briar Hill (No. 5A) Coal Member. This is a thin, discontinuous coal known in southeastern Illinois. It is of little commercial importance. It occurs in Gallatin and Saline counties within a zone of sandy strata. It reaches 18 to 30 inches in the Eagle Valley Syncline, but its thickness is very erratic.

- Herrin (No. 6) Coal Member. This is a bright-banded coal which ranks first in commercial importance in the state. The thickness pattern of the No. 6 coal is unlike that of most of the Pennsylvanian units in southern Illinois. The No. 6 coal tends to thicken going from eastern Gallatin County, where it tends to be less than 4 feet thick, toward western Williamson and northeastern Jackson County, where it attains a thickness of 8 to 9 feet. However, right in the middle of this zone of thick coal, there is a coal cutout; this is caused by sandstone channel located approximately along the border of Williamson County with Perry and Jackson counties. West of the cutout, the coal thins to the 5-to-7-foot range.

- Jamestown Coal Member. This is a thin coal, seldom more than a few inches thick. Four to six inches is the usual thickness in the eastern counties.

- Danville (No. 7) Coal Member. This coal was formerly known in southwest Illinois as the Cutler Coal. It reaches a maximum thickness of about 18 inches in southwestern Illinois and up to a maximum of 30 inches in the southeastern counties.

The stratigraphic interval between the No. 5 and No. 6 coals is of importance because it occurs as spoil material in many strip mines in southern Illinois. The thickness of this sequence of rocks varies considerably, from about 125 feet in eastern Gallatin County to less than 25 feet in western Perry County. In general, the thicker eastern portion of this inteval is characterized by a higher percentage of sandstone than further west, and the shales are also thicker. Where the distance between the two coals is thin, limestones and clay predominate, and the clays and shales tend to be limey. In contrast to this, there is less than a foot of limestone present in much of the eastern area. This lack of neutralization potential, coupled with the presence of pyrite in the rocks above the No. 5 coal, allows the formation of acidic mine drainage water where the No. 5 coal has been surface mined in southeastern Illinois.

The Carbondale Formation rocks above the No. 6 coal present a different environmental situation. Although pyrite is present in some units, especially the Anna Shale Member, there are enough limestones in the section to neutralize acids generated by oxidative weathering. As a result, water draining from overburden that contains upper Carbondale Formation rocks commonly has high sulfate, hardness, and total dissolved solids, but usually has alkalinity exceeding acidity and neutral to above-neutral pH.

Modesto Formation. The Modesto Formation is the youngest Pennsylvanian formation found in most of the coal-producing area of southern Illinois. Thickness of the Modesto Formation is 225 feet in most of Perry County. East of the DuQuoin Monocline, thickness increases to over 375 feet in northeast Williamson County and thins again to a little over 300 feet thick in northernmost Saline and Gallatin counties.

The Modesto Formation is characterized by gray shale, but sandstones are locally prominent. The approximate distribution of lithologies is about 70% shale, 25% sandstone, 5% limestone, and less than 1% coal (Figure 6). It has thicker limestones and thinner coals than the underlying Carbondale Formation, and the presence of red shales also serves to distinguish it from the older formation. Coals in this formation are less than a foot thick and are not usually of commercial importance.

Only one member of this formation merits mention here. The Piasa Limestone Member (formerly called the Cutler Limestone) lies a few feet above the No. 7 coal. It is generally less than 4 feet thick in the southwestern part of the region but thickens to about 15 feet toward the east, where it is known as the West Franklin Limestone. This is a persistent limestone horizon which, because of its stratigraphic position in the lower part of the Modesto Formation, may occasionally be encountered in strip mine overburden in areas where the Carbondale Formation is thin (i.e., west of the DuQuoin Monocline).

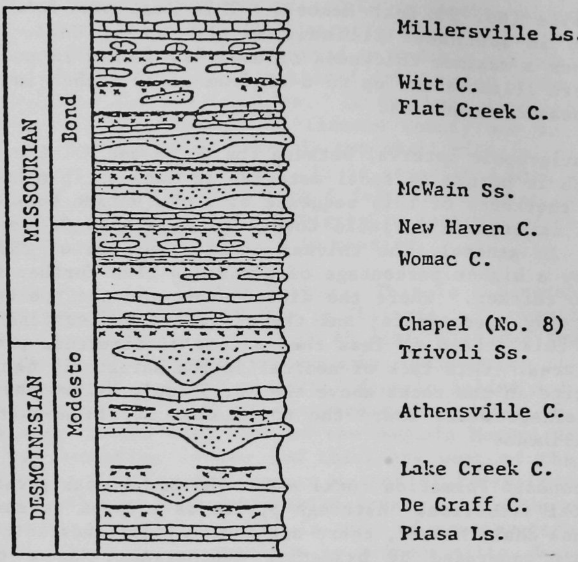


Fig. 6 Generalized Stratigraphic Section of the Modesto and Bond Formations (after Hopkins and Simon, 1970)

1.5 SOILS

Soils in the vicinity of the Mine IL-1 are upland silt loams that have developed under both forest and prairie vegetations. The Cisne-Hoyleton association is composed of silt loams that have developed under grassland vegetation on parent material consisting of a thick loess cover (up to 6 or 7 feet) over weathered glacial till. Soils in this association have dark surface layers, light A_2 horizons and B horizons that extend into the till beneath the loess. Both have gray, silty clay loam B horizons. Both soils have developed on nearly level areas. Permeability through the subsoil is poor. Soils of this association are acid, with Cisne soils typically having a pH in the range of 4 to 5 and Hoyleton varying from 4.7 to 5.4.

The second major association in the mine area is the Ava-Blueford-Wynoose association. These soils are silt loams that developed under forest vegetation on parent material consisting of loess over till. Wynoose silt loam soils develop on slopes of 0 to 2%, Bluford on slopes of 1 to 4%, and Ava on slopes of 3 to 7%. All of these have silty, light-colored surface layers and very clayey subsurface horizons. All are acid, with Wynoose ranging from pH 4.0 to 4.4, Bluford about 4.5, and Ava from 4.4 to 4.6.

Soils of the Bonnie-Belknap association are bottomland soils, occurring in the larger stream valleys on surfaces with 0 to 2% slope. Bonnie is present in the wide bottomlands and Belknap in the upper reaches of the streams. They are formed on alluvial sediments and have basically a silt loam texture throughout, with some sand lenses and pebbles scattered within the soils. Both are dark gray to gray-brown. Bonnie tends to be poorly drained and has a pH of about 4.7 in the upper 15 inches, with lower pH values occurring at depth. Belknap is better drained and has a pH of about 5.3 (Miles et al., 1970).

1.6 HYDROLOGY

Surface Water. The study mine is located in the upper reaches of a rather small stream for which little data are available. The Greater Egypt Regional Planning and Development Commission has conducted a regional surface water survey that included a station on this stream several miles downstream from the mine. During the period of May through December 1976, flow at this station ranged from 0 to 20.5 cfs and averaged about 2.5 cfs. Other parameters of interest are listed below (values in mg/L, except for pH).

Iron:	0.4 to 6.9; avg. 1.7.
Hardness:	310 to 980; avg. 633.
Sulfate:	400 to 4000; avg. 1905.
Total Dissolved Solids:	1110 to 5670; avg. 3706.
Total Suspended Solids:	12 to 200; avg. 71.
pH:	7.3 to 8.8.

Groundwater. Generally only a small to moderate amount of water seeps from the highwall or spoil into the open pit. The only time water is a problem in the pit is during periods of heavy rainfall. Flow into the pit is slow enough that one sample station selected to monitor pit water was discontinued for lack of discharge. Evidence of water movement through older spoil material, in contrast to undisturbed or recently mined material, can be observed at the pumping station at which water for the washing plant is obtained. This pit is filled by underground water flow from old spoil and possibly recirculation from the slurry pond. Geologically, most of the mine area is not very favorable for groundwater, since Lower Pennsylvanian sandstones, which might potentially be aquifers, are either thin or missing.

Davis (1973) examined the regional water quality in wells that were less than 250 feet deep. The general tendency in the area is for the water to contain 160 ppm or more chloride, high hardness (over 500 ppm as $CaCO_3$), and high iron (greater than 40 ppm). Sulfate is generally in the 400 to 800 ppm range. Waters with such characteristics are not potable. Although exceptions to these general tendencies exist, they are infrequent enough that almost all the intensive water use is from surface reservoirs.

2 SITE CHARACTERISTICS, SAMPLING, AND ANALYSES

2.1 MINE OPERATION

The mine opened in the mid-1960s and has produced coal ever since that time. Annual production has declined from around 4.5 million tons in the early 1970s to about 3.5 million tons in the late 1970s.

During the last stages of this study, the mine underwent an expansion with the opening of an additional pit. The life expectancy of the mine is not known, but it should be in production for well over ten years.

Mining at the IL-1 is by the area method. In the portion of the mine studied for this report, mining was initiated with a box cut. A large shovel, a Marion 6360 with 180 cubic yards capacity, removes the overburden over the No. 6 coal, after which the No. 6 coal is removed. Subsequently, the parting between the No. 6 and No. 5 coals is removed, allowing extraction of the No. 5 coal. The size of the shovel is such that the spoil is piled so high it tends to be unstable. Therefore, a small dragline, a Page 752, is used as a pullback machine, removing the tops of the spoil piles and filling the depressions between piles. Bulldozers subsequently level the area to grades required by law. Topsoil is scraped by pan scrapers from in front of the advancing pit and is then piled on the graded spoil as required under Illinois law.

During the life of this study, a second pit was opened at the mine. This is being mined in a similar manner, except that overburden removal is by dragline rather than by shovel.

The mine effluent is not treated to alter its chemical quality. Water pumped from the active pits is routed through settling ponds which have been designed to provide a residence time of 41 to 72 hours, depending on the individual pit.

2.2 SAMPLING POINTS AND METHODS

The sampling points were selected to conform as nearly as possible to Argonne's requirements as understood by the investigator. One site that was selected to sample pit pumpage water was abandoned because of the lack of pumping on virtually every sampling date; hence no sample of water as it came directly from the pit is available. The individual sampling sites are described below.

301 Main drainage, on the receiving stream, at a point just above where the stream leaves the mine. The main drainage at this point contains water from above mine site, water from a sewage plant, and water pumped from pits. The drainage is not in its natural channel but is in a drainage ditch dug to divert the water around the mining operation.

302 Main drainage of the area prior to significant influence of mining. The stream is in a manmade channel at this point, but sampling at this location was necessary because of discharge from a sewage plant entering the stream in the channelized sector. Sampling above the sewage infall would have given the impression that the mining operation was responsible for any pollutants that might be present in the sewage plant discharge.

303 Discharge from a network of settling ponds associated with the original pit location at the time sampling started.

304 Discharge from a settling pond dug to accommodate water pumped from the new pit position which was created after the initiation of sampling.

305 Water draining a relatively small area of old spoil.

306 Slurry from the coal cleaning operation.

307 Intake water for the coal cleaning operation.

A generalized flow diagram illustrating the relationship of these sampling points to one another is shown in Figure 7. The locations of the sampling sites, except for 307 which is east of the map area, are shown in the accompanying map (Figure 8).

Highwall Sampling. The highwall of the northern pit was sampled by conventional channel sampling during the spring of 1976. The factors governing the exact location of the channel were accessibility of the face and safety of the sampling crew. Relatively thick overburden and loose rock made sampling hazardous. A brief lithological description of the highwall rocks is given in Table 2 and is shown graphically in Figure 9.

Highwall Chemistry. Partial chemical analyses of the overburden samples are given in Table 3. With the exceptions of iron and manganese, these analyses concentrate on heavy elements (Zn, Cd, Co, Cr, Cu, Pb, Ni, and Hg) and not on the common rock-forming elements. The values are, in general, typical for sedimentary rocks except for some of the cadmium values, which tend to be higher than is common for sedimentary rocks.

An attempt was made to determine the maximum amount of the elements above that might be leached from the overburden rocks under optimum conditions. This was done by leaching 10 grams of pulverized rock with 20 mL of 1 + 1 nitric acid at 60°C for 20 minutes. The amounts of the various elements leached from the rocks, converted to part per million of the whole rock, are given in Table 4. Under these conditions manganese is the most easily leached element with an average of 75% of the manganese being leached from the overburden rocks. Lead and chromium are the least easily mobilized, with 12% and 13% of these elements being removed, respectively. The remainder of the elements show extractabilities between 21% and 67%.

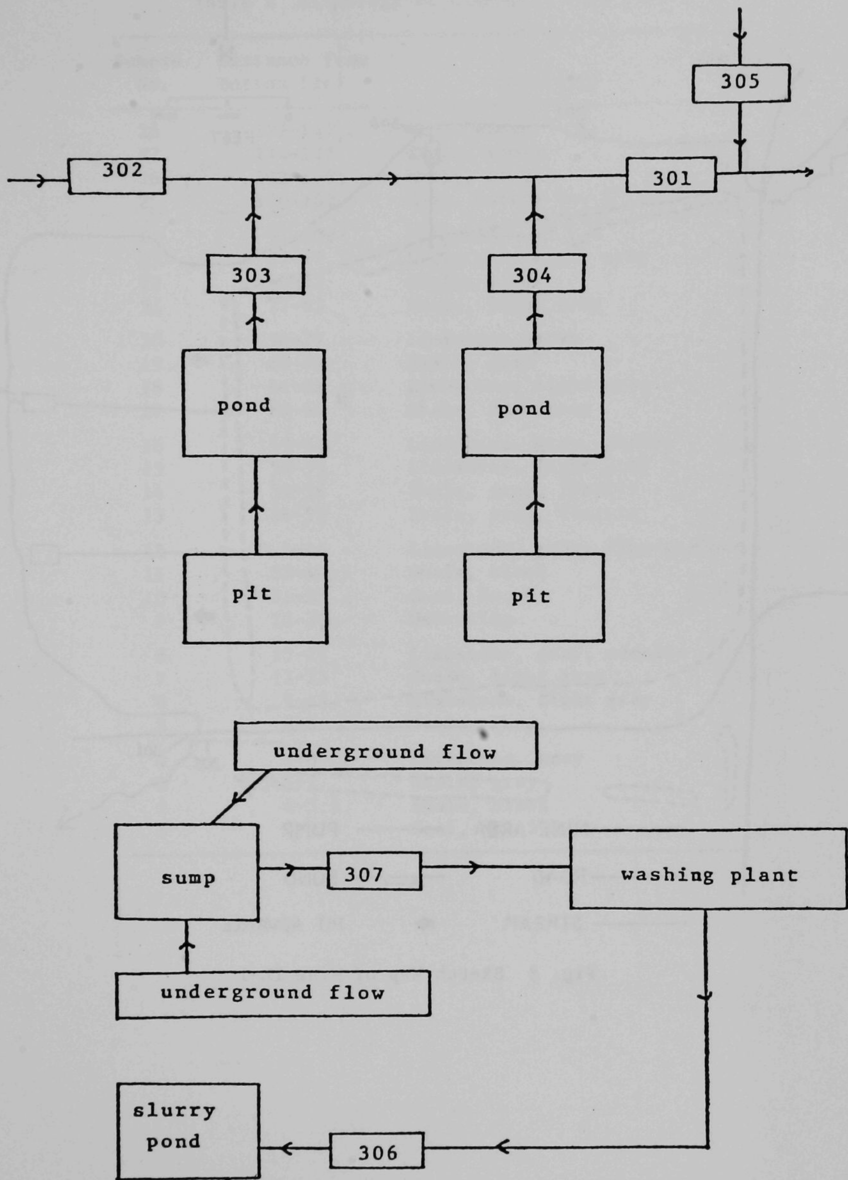


Fig. 7 Generalized Flow Diagram of Mine IL-1

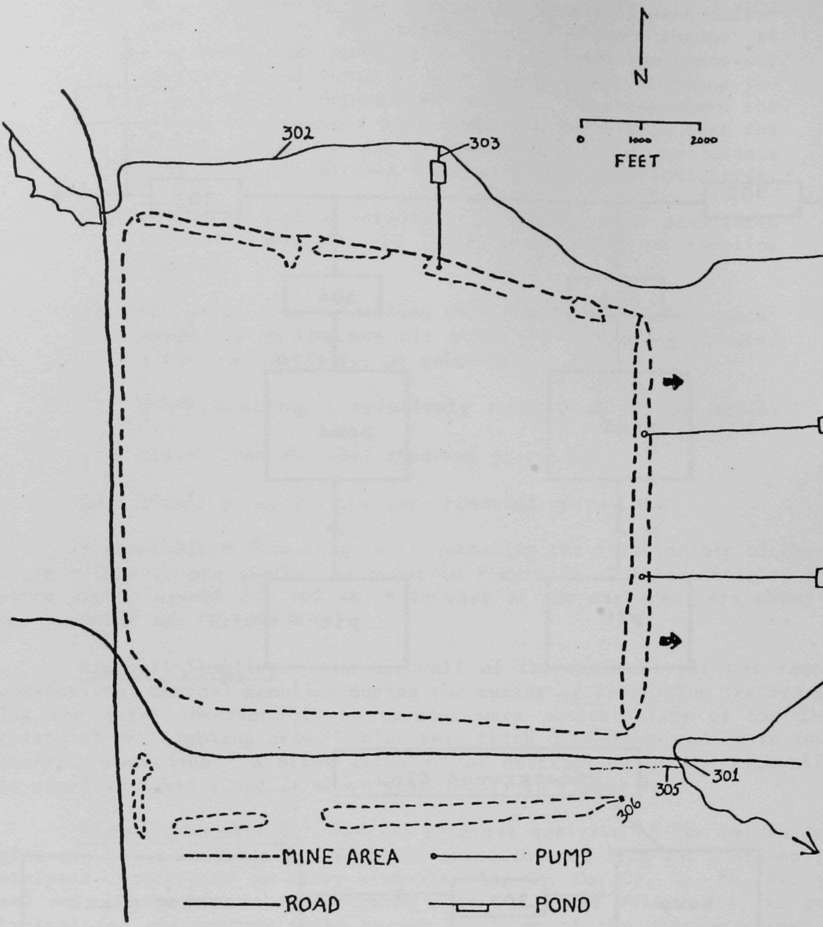
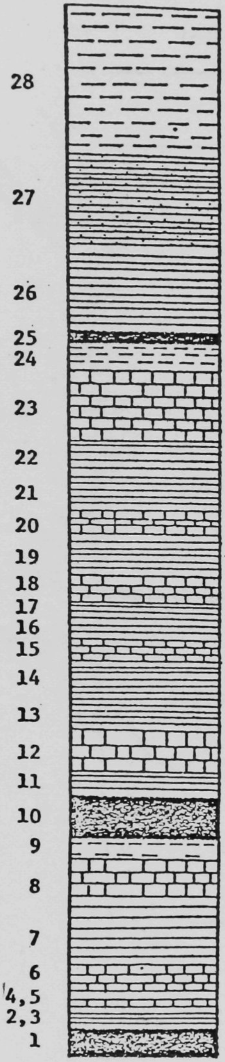


Fig. 8 Sketch Map of Mine IL-1

Table 2 Lithology of Highwall, Mine IL-1

Sample No.	Distance from Bottom (ft)	Lithology
28	127-147	Clay, brown
27	114-127	Shale, sandy
26	102-114	Shale, gray
25	100-102	Coal, Cutler No. 6
24	97-100	Underclay
23	87-97	Limestone, light gray
22	83-87	Shale, black
21	77-83	Shale, light gray
20	74-77	Limestone, gray
19	68-74	Shale, gray
18	64-68	Limestone, light gray
17	63-64	Shale, dark gray
16	59-63	Limestone, gray, shaley
15	56-59	Limestone, light gray
14	51-56	Shale, gray, fissile
13	46-51	Shale, gray, fissile
12	40.5-46	Limestone, gray, fine-grained
11	37-40.5	Shale, black
10	31-37	Coal, No. 6
9	28-31	Underclay
8	23-28	Limestone, gray, massive
7	13-23	Shale, light gray
6	9-13	Limestone, light gray
5	8-9	Shale, gray
4	7-8	Limestone, gray
3	5.5-7	Shale, gray
2	4-5.5	Shale, black
1	0-4	Coal, No. 5



Unit	Lithology	Thickness (ft.)
28	Clay, brown	10-40
27	Sandy Shale	12
26	Gray Shale	10
25	Cutler #6 Coal	1.5
24	Underclay	3
23	Light Gray Limestone	10
22	Dark Gray Shale	4
21	Light Gray Shale	6
20	Gray Limestone	3
19	Greenish-Gray Shale	6
18	Light Gray Limestone	4
17	Dark, Grey, Fissile Shale	1
16	Gray Shaley Mudstone	4
15	Gray Limestone	3
14	Gray Fissile Shale	5
13	Gray Fissile Shale	5
12	Massive Grey Limestone	6
11	Black Carbonaceous Shale	1
10	No. 6 Coal	5
9	Underclay	3
8	Light Gray Limestone	5
7	Light Gray Shale	10
6	Light Gray Limestone	3
5	Gray Shale	1
4	Gray Limestone	1.2
3	Gray Shale	1
2	Black Carbonaceous Shale	2
1	No. 5 Coal	4

Vertical Scale: 1 inch = 10 ft

Fig. 9 Generalized Highwall Section, Mine IL-1

Table 3 Total Heavy Metals, Mine IL-1 Highwall

Sample No.	Fe	Mn	Zn	Cd	Co	Cr	Cu	Pb	Ni	Hg
28	24,590	604	78.9	4	23.2	50.1	14.0	206	16.0	0.372
27	74,410	1240	396	6	28.0	73.9	50.0	40	44.0	0.090
26	48,740	1530	59.8	16	37.2	65.9	32.0	198	85.0	0.247
25	36,150	154	63.9	46	117	18.0	20.0	152	32.1	0.091
24	20,000	148	109	14	28.0	106	34.0	70	71.1	0.169
23	22,310	733	71.7	4	28.0	12.0	336	28	44.0	0.300
22	34,990	186	17.9	6	41.8	232	110	60	158	0.511
21	32,250	573	42.0	16	18.6	89.9	30.0	308	38.0	0.028
20	18,390	1630	25.9	10	23.2	18.0	18.0	16	37.9	0.034
19	19,840	813	47.9	12	14.0	66.0	24.0	244	32.0	0.434
18	11,060	1098	226	10	18.5	23.8	11.9	139	31.8	0.058
17	23,050	331	212	10	32.5	91.7	25.9	157	37.9	0.047
16	35,870	446	82.0	6	32.3	67.4	39.7	206	106	0.228
15	22,760	2070	11,800	20	23.2	24.0	12.0	59.9	50.0	0.193
14	30,660	820	186	12	116	73.8	21.9	291	37.9	0.427
13	23,790	638	124	18	28.0	102	30.0	32	50.0	0.407
12	24,040	723	70.1	14	37.1	26.0	16.0	59.9	87.9	0.544
11	28,360	40.0	16.0	22	80.4	272	103	290	137	0.071
10	16,460	114	1000	3	14.0	15.0	8.0	105	16.0	0.096
9	14,040	202	188	22	23.2	78.2	32.1	92.2	38.1	19.900
8	9,930	1324	40.0	4	8.0	40.0	11.4	118	38.0	0.020
7	16,770	473	56.0	4	23.2	108	22.0	80.2	44.1	0.043
6	38,650	2120	20.0	6	33.0	44.0	14.0	88.0	44.0	0.092
5	30,900	150	46.1	4	43.8	131	48.0	22.0	120	0.059
4	15,240	1720	16.0	4	25.8	30.0	10.0	30.0	50.0	0.076
3	37,280	483	42.1	16	94.6	222	108	326	186	0.013
2	23,230	54.9	48.9	12	19.4	948	232	30.0	368	0.031
1	10,360	181	431	12	28.0	14.0	4.0	130	32.0	0.082

Table 4 Acid-Leachable Heavy Metals, Mine IL-1 Highwall

Sample No.	Fe	Mn	Zn	Cd	Co	Cr	Cu	Pb	Ni	Hg
28	10,230	430	29.7	0.8	10.4	6.4	8.9	3.3	14.6	0.005
27	26,280	893	51.9	0.8	15.2	10.5	26.8	2.0	31.8	0.020
26	35,900	1400	166	1.4	18.2	11.6	24.0	3.6	36.0	0.016
25	30,760	136	8230	11.7	7.0	2.1	16.7	58.6	19.6	0.078
24	9,990	97.0	48.5	0.5	11.3	7.7	24.0	8.0	34.2	0.021
23	640	457	2.4	2.2	13.5	5.2	5.2	11.5	13.2	0.001
22	30,130	149	201	2.6	19.0	31.1	76.2	13.1	148	0.089
21	8,110	456	10.5	0.1	12.1	3.6	17.8	3.8	37.1	0.008
20	2,680	1010	13.0	1.8	12.1	4.8	13.4	3.1	11.1	0.009
19	8,880	635	15.5	1.4	11.6	5.9	15.8	6.5	18.6	0.013
18	7,110	258	8.5	1.9	12.4	5.5	8.2	4.4	12.4	0.004
17	12,650	278	43.4	1.7	11.9	5.9	18.7	3.1	33.9	0.007
16	17,830	447	84.3	0.9	16.8	7.1	29.8	6.0	55.8	0.007
15	15,630	1670	13.5	2.0	12.9	6.8	8.5	3.3	15.6	0.005
14	16,220	749	82.9	2.6	14.8	6.2	17.2	2.8	34.7	0.007
13	20.920	592	92.1	18.5	18.5	8.2	23.1	4.1	49.4	0.008
12	2,050	637	8.1	14.2	14.2	6.0	10.8	9.1	20.6	0.038
11	17,050	120	492	16.2	16.2	21.0	77.8	2.1	128	0.038
10	15,920	44.9	47.7	5.7	5.7	0.1	4.8	1.7	6.7	0.024
9	7,630	418	4.0	14.2	14.2	2.6	19.5	5.3	31.6	0.032
8	8,160	1600	8.2	11.7	11.7	6.7	6.6	4.3	10.6	0.002
7	14,610	104	15.6	3.3	3.3	1.0	12.3	5.8	8.1	0.019
6	38,810	167	11.6	14.2	14.2	9.5	7.7	1.7	16.7	0.009
5	25,000	444	36.5	24.1	24.1	5.4	31.7	3.4	79.3	0.008
4	14,080	1310	8.8	16.0	16.0	6.2	9.2	3.6	20.9	0.000
3	3,290	157	149	28.8	28.8	11.8	76.4	9.6	151	0.016
2	20,260	65.0	708	16.5	16.5	113	165	29.4	202	0.048
1	7,680	19.2	5.0	1.7	1.7	1.0	3.4	2.5	4.8	0.067

Net Neutralization Potential. Most units of the highwall show both an acid potential and a neutralization potential (Table 5). For most units of this mine, neutralization potential exceeds the acid potential, giving a positive net neutralization potential. This is shown in Figure 10. By means of the net neutralization potential of each unit weighted by the thickness of that unit in the highwall, an overall net neutralization potential can be calculated for the mine. This value is 189 tons of $CaCO_3$ per 1000 tons of overburden. The two mined coal beds are excluded from this calculation.

2.3 COAL ANALYSES

Both the Harrisburg (No. 5) and the Herrin (No. 6) coals are being mined at IL-1. The minor element chemistries of the two coals were determined at the same time as the overburden and are included with those data (Table 3, analyses 1 and 10).

A proximate and an ultimate analysis of the combined production from the two seams were available from the company and are presented in Table 6. Additional average data for the No. 5 and No. 6 coals in the mine area given in the Keystone Coal Manual (Table 7 and Table 8, respectively).

2.4 WATER ANALYSES

Flow. No flow data were routinely collected. Some flow data were collected at two stations during the last few months of the project; these are tabulated in Appendix E and presented graphically in Figures 11 and 12.

Dissolved Oxygen. The water coming into the mine shows a poorly developed tendency for higher dissolved oxygen values to be present when water temperatures are low. In spite of wide differences in temperature, there does not seem to be any well-developed seasonal trend in dissolved oxygen for the other sample stations.

pH. No seasonal trends were observed in pH. No pH problems exist in this area, as almost all of the values measured in the field were between 7 and 8.5. Even in the slurry pond circuit the water retained its high pH nature. The high pH is a function of the large positive net neutralization potential; there is enough neutralization potential to more than neutralize any acid that might be produced through oxidative weathering of pyrite.

Temperature. The only trend observed for this parameter is the seasonal variation expected from the climate of the area.

Conductivity. Conductivity shows a seasonal trend, generally being lower in winter than in spring and summer.

On most sampling dates, conductivity increases as the water passes through the mine area. The increase is often by a factor of two or more. This is a reflection of the relatively high conductivity of water being

Table 5 Sulfur Forms and Acid-Base Balance for Overburden

Sample No.	Depth (ft)	Munsell Value and Chroma	Lithology	Sulfur Fraction (%)			Tons $CaCO_3$ Equivalent/1000 Tons Material	
				Total Sulfur	Sulfate Sulfur	Sulfide Sulfur	Acid Potential	Neutralization Potential
18	20-0	10 YR 6/6	Clay	0.02	0.01	0.01	0.2	41.3
17	33-20	10 YR 7/4	Shale, sandy	0.04	0.01	0.03	1.0	23.9
16	45-33	5 YR 6/1	Shale	0.21	0.02	0.19	5.9	18.1
15	47-45	N 2	Coal	5.58	0.48	5.10	159.4	21.6
14	47-50	N 7	Underclay	0.53	0.08	0.45	14.0	24.2
13	60-50	5 YR 8/1	Limestone	0.30	0.17	0.13	4.1	557.7
12	64-60	N 7	Shale	3.03	0.69	2.34	73.0	6.5
11	70-64	N 7	Shale	1.15	0.13	1.02	31.8	143.4
10	73-70	5 YR 8/1	Limestone	0.25	0.06	0.19	6.1	542.6
9	79-73	N 7	Shale	1.01	0.16	0.85	26.4	431.2
8	83-79	N 7	Limestone	0.16	0.03	0.13	4.2	542.6
7	84-83	5 YR 6/1	Shale	1.10	0.11	0.99	30.8	232.7
6	88-84	N 5	Limestone, shaley	1.42	--	2.55	79.8	20.4
5	91-88	N 6	Limestone	0.41	0.03	0.38	11.8	522.9
4	96-91	N 5	Shale, fissile	1.52	0.18	1.34	41.8	289.7
3	101-96	N 4	Shale, fissile	1.86	--	1.90	59.4	226.3
2	106.5-101	N 7	Limestone, fine-grained	0.46	0.0	0.41	12.8	550.7
1	110-106.5	5 YR 2/1	Shale	2.48	0.14	2.34	73.0	30.3
0	116-110		Coal	3.96	0.14	3.82	119.3	23.9
9C	119-116	5 YR 6/1	Underclay	0.75	0.34	0.41	12.7	214.7
8C	124-119	N 8	Limestone, massive	0.48	0.06	0.42	13.1	541.4
7C	134-124	N 8	Shale	1.47	0.14	1.33	41.6	38.4
6C	138-134	N 8	Limestone	0.26	--	0.27	8.6	519.4
5C	139-138	N 7	Shale	2.83	0.29	2.54	79.4	239.7
4C	140-139	N 7	Limestone	0.45	0.16	0.29	9.1	539.1
3C	141.5-140	5 YR 6/1	Shale	2.93	0.23	2.70	84.5	75.0
2C	143-141.5	N 1	Shale	2.27	0.01	2.28	71.1	37.8
1C	143-147	N 1	Coal	3.02	0.04	2.98	93.0	34.4

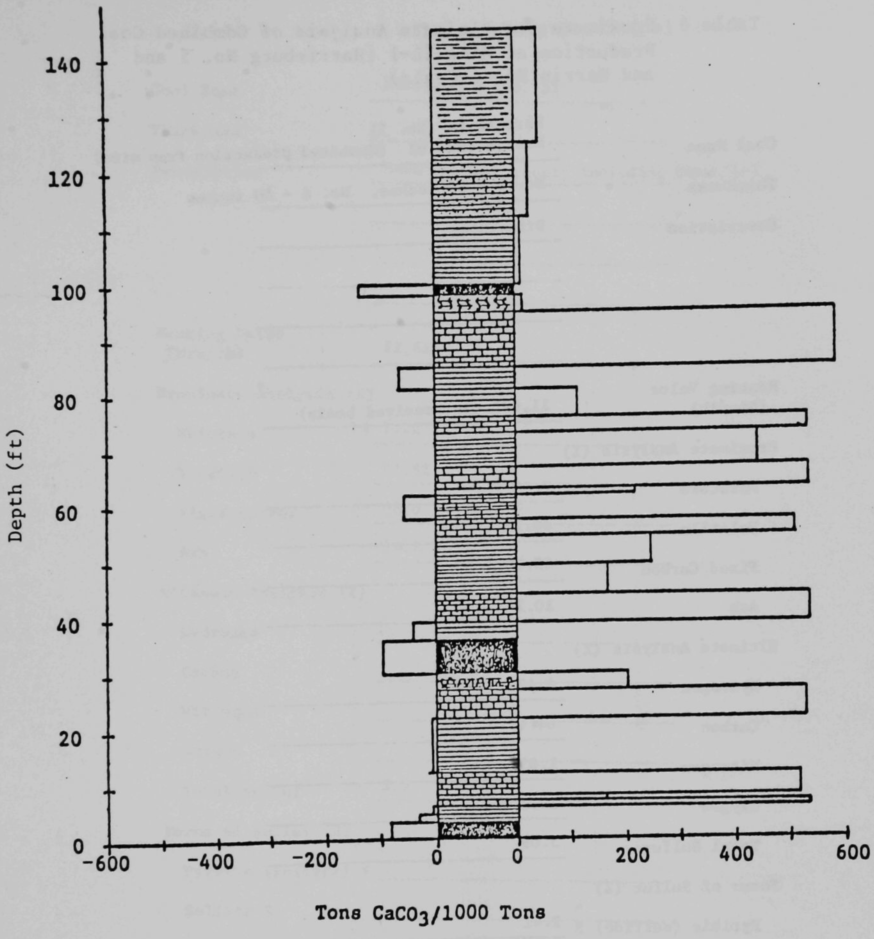


Fig. 10 Acid-Base Balance, Mine IL-1

Table 6 Proximate and Ultimate Analysis of Combined Coal Production at Mine IL-1 (Harrisburg No. 5 and and Herrin No. 6 Coals)

Coal Name	Harrisburg (No. 5) Herrin (No. 6) (Combined production from mine)
Thickness	No. 5 - 48 inches, No. 6 - 40 inches
Description	Bituminous
Heating Value (Btu/lb)	11,675 (as received basis)
Proximate Analysis (%)	
Moisture	7.66
Volatile	36.22
Fixed Carbon	45.38
Ash	10.74
Ultimate Analysis (%)	
Hydrogen	4.42
Carbon	64.47
Nitrogen	1.03
Oxygen	8.50
Total Sulfur	3.09
Forms of Sulfur (%)	
Pyritic (sulfide) S	2.41
Sulfate S	0.02
Organic S	0.66
Total S	3.09
Source of Analytical Data	Coal Company

Table 7 Analysis of Harrisburg No. 5 Coal

Coal Name	Harrisburg (No. 5)
Thickness	
Description	Mean values, county including Mine IL-1
Heating Value (Btu/lb)	12,616
Proximate Analysis (%)	
Moisture	7.2%
Volatile	41.8%
Fixed Carbon	48.0
Ash	10.2
Ultimate Analysis (%)	
Hydrogen	
Carbon	
Nitrogen	
Oxygen	
Total Sulfur	3.9
Forms of Sulfur (%)	
Pyritic (sulfide) S	
Sulfate S	
Organic S	
Total S	
Source of Analytical Data	Keystone Coal Manual (1975)

Table 8 Analysis of Herrin No. 6 Coal

Coal Name	Herrin (No. 6)
Thickness	
Description	Mean values, raw coal
Heating Value (Btu/lb)	12,080
Proximate Analysis (%)	
Moisture	9.6
Volatile	39.5
Fixed Carbon	46.2
Ash	14.2
Ultimate Analysis (%)	
Hydrogen	
Carbon	
Nitrogen	
Oxygen	
Total Sulfur	3.9
Forms of Sulfur (%)	
Pyritic (sulfide) S	
Sulfate S	
Organic S	
Total S	
Source of Analytical Data	Keystone Coal Manual (1975)

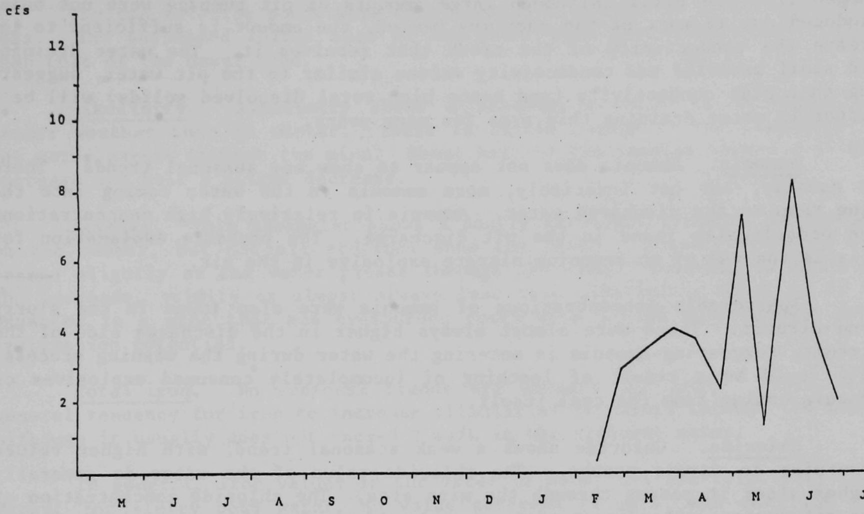


Fig. 11 Flow, Station 301

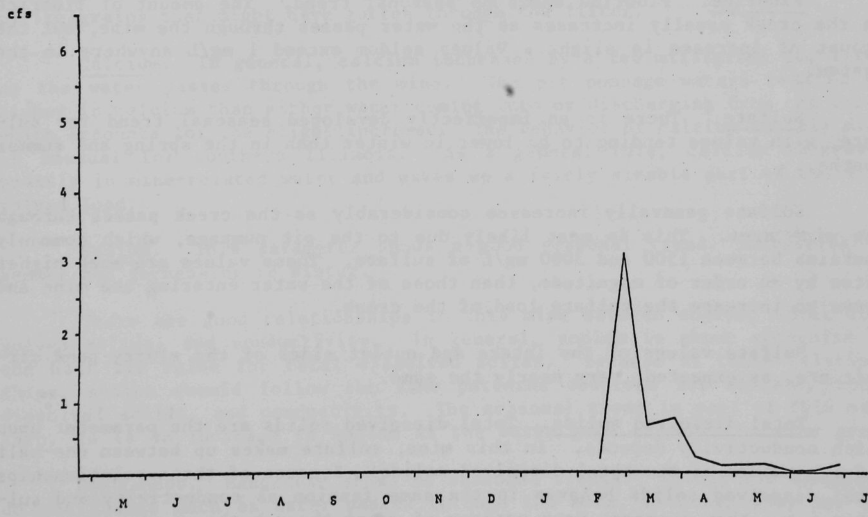


Fig. 12 Flow, Station 302

pumped from the pits. Although large amounts of pit pumpage were not being produced during most of the sampling period, the amount is sufficient to increase the conductivity of the creek that receives it. The water draining old spoil material has conductivity values similar to the pit water, suggesting that high conductivity (and hence high total dissolved solids) will be a factor in water draining this area for many years.

Ammonia. Ammonia does not appear to show any seasonal trends. There is usually, but not invariably, more ammonia in the water coming into the mine than in the discharge water. Ammonia in relatively high concentrations was occasionally found in the pit discharge. The probable explanation for this is the use of an ammonium nitrate explosive in the pit.

Appreciable concentrations of ammonia were also found in the slurry pond circuit. These were almost always higher in the discharge side of the circuit, suggesting ammonia is entering the water during the washing process. This could be a result of leaching of incompletely consumed explosives or ammonia coming from the coal itself.

Chloride. Chloride shows a weak seasonal trend, with higher values occurring in warmer months. The chloride value of the water is generally higher after it passes through the mine area. The chloride concentration of the pit pumpage water is at times considerably higher than is typical of surface water in southern Illinois. The chloride appears to be derived by rainfall leaching chloride from some of the overburden rocks. Many of the rocks in the highwall appear to be of marine origin, and it is possible that small amounts of chloride still remain trapped within them.

Fluoride. Fluoride shows no seasonal trend. The amount of fluoride in the creek usually increases as the water passes through the mine, but the amount of increase is slight. Values seldom exceed 1 mg/L anywhere in the system.

Sulfate. There is an imperfectly developed seasonal trend for sulfate, with values tending to be lower in winter than in the spring and summer months.

Sulfate generally increases considerably as the creek passes through the mine area. This is most likely due to the pit pumpage, which commonly contains between 1500 and 3000 mg/L of sulfate. These values are much higher, often by an order of magnitude, than those of the water entering the mine and serve to increase the sulfate load of the creek.

Sulfate values of the intake and outlet sides of the slurry pond circuit are, as expected, very nearly the same.

Total dissolved solids. Total dissolved solids are the parameter upon which conductivity depends. In this mine, sulfate makes up between one-half and two-thirds of the total dissolved solids. Because of these relationships, total dissolved solids behaves in the same fashion as conductivity and sulfate; i.e., they increase upon passage of water through the mine.

Suspended solids. No seasonal trend was apparent in this parameter. The amount of suspended solids is generally higher in the water leaving the mine than in the water as it enters the mine.

The two settling ponds were considerably different in their effectiveness. The suspended solids load of the older pond was considerably higher than that of the newer pond.

Alkalinity. Alkalinity shows a seasonal trend. It is higher in warmer weather than in winter. There is little change in the parameter as the water passes through the mine. About half of the samples showed a slight increase and half a slight decrease.

Acidity. This parameter shows a poorly developed trend of increasing in the summer, but not all stations show the trend. Acidity tends to increase slightly as the water passes through the mine. However, in spite of the increase, acidity is almost always less than alkalinity, which is to be expected in a mine that has overburden rocks with a high positive net neutralization potential.

Total iron. No seasonal trends are present for iron. There is a general tendency for iron to increase slightly as it passes through the mine, although it usually does not exceed 2 mg/L in the effluent water.

In general, iron values in the water at Mine IL-1 are relatively low. Except for slurry pond water, no value exceeded 12 mg/L, and only 16% exceeded 2 mg/L.

In the slurry pond circuit, iron was generally low except on two occasions, when values of 57.9 and 91.5 mg/L were recorded. The cause of these two abnormally high values is not certain, but because they are both on the dicharge side of the circuit, perhaps they are due to dissolution of small pyrite grains that might have gotten through the filter.

Calcium. In general, calcium increases by a few milligrams per liter as the water passes through the mine. The pit pumpage waters tend to be higher in calcium than either water coming into or discharging from the mine, which accounts for the slight increase. The behavior of calcium in this mine is unusual for southern Illinois. As a general rule, calcium increases greatly in mine-related water and makes up a fairly sizable part of the dissolved load.

Sodium. This parameter shows a good seasonal trend, increasing in summer and decreasing in winter.

There are good relationships in this mine between sodium, total dissolved solids, and conductivity. In general, sodium is about one-third to one half the value for total dissolved solids. Because of these relationships, sodium should follow the same patterns observed for sulfate, total dissolved solids, and conductivity. The seasonal trend is part of this pattern, as is an increase in sodium as the water goes through the mine area.

Manganese. Manganese shows no seasonal trends. Values for manganese do not change much as water passes through the mine, although they may increase very slightly. Manganese concentrations are almost always less than 1 mg/L. The highest values of manganese are associated with drainage from an old spoil area. Although higher than the values from the present mine area, these values are also generally less than 1 mg/L.

Aluminum. Aluminum does not show any seasonal trend. Although the aluminum values are erratic, there is a slight tendency for the values to increase slightly as the water passes through the mine. The aluminum values are high for a water with a near neutral pH.

Copper. This element shows no seasonal or geographical trends. It is present in only very small quantities and seldom reaches concentrations as high as 0.1 mg/L.

Zinc. Zinc, like copper, shows no seasonal or geographic trends. Values seldom exceed 0.05 mg/L.

Strontium. Strontium shows a slight tendency to increase in warmer months in the mine-related water. The waters of the creek increase in strontium content as they pass through the mine area.

2.5 TREATMENT EFFECTIVENESS

The only treatment being given to the water occurs when water pumped from the pit passes through the settling ponds. Water from the mine has to meet whatever environmental standards are established, so the final effluent will also be evaluated in terms of the various reference values Argonne has suggested.

pH. Water leaving the settling ponds and the final effluent leaving the mine would have no trouble meeting standards of pH between 6 and 9.

Total iron. Water from the settling ponds exceeded the daily maximum value of 7.0 mg/L only twice during the course of the study. At the pH values of the water, most of the iron should be in particulate form, so that slightly larger settling ponds would probably make this value attainable. For the effluent leaving the property, the value of 7 mg/L was never exceeded, so the water easily could meet such a requirement.

Settling pond discharge exceeded the maximum daily value of 3.5 mg/L 6 out of 23 times, or 26% of the time. This would suggest the settling ponds are not currently effective enough to reach this value. Either they would have to be enlarged to allow a longer residence time, or some treatment such as the addition of flocculent would have to be initiated. On the other hand, as the creek passes out of the mining area, total iron exceeded 3.5 mg/L only twice. It would appear that a 3.5 mg/L daily maximum could be met, but it would probably require larger settling ponds for the pit discharge or a settling area on the creek itself.

For 30-day average values, the data collected in this study cannot be used directly because the samples were collected only twice a month. One can make a rough approximation by examining back-to-back samples and assuming that each sample is representative of a 15-day period. Thus, two back-to-back samples with high values could be taken to be a month of high daily values for purposes of evaluating the probability of the water's exceeding a particular value.

Pit discharge water would have exceeded a maximum value of 3.5 mg/L for about 1.5 months out of the 13 months of the study. The mine effluent would not have exceeded this value during the entire study period.

Pit discharge would have exceeded a maximum value of 3.0 mg/L for about 1.5 months out of 13. The mine effluent would have exceeded the value one month out of the 13.

Total manganese. A value of 4 mg/L daily maximum or a value of 2.0 mg/L 30 day average for total manganese was easily met by pit discharge and mine effluent during the entire sampling period.

Total suspended solids. For a value of 10 mg/L suspended solids, the settling ponds are not very effective, attaining this value only about half of the time. The creek water seldom gets below this value. The mine, with its present practices, would be in nearly constant violation if this value were the standard. This is something that could be expected in view of the fact that the creek is channeled around the mine and occupies a fresh, unlined, and unstable (from a geologic perspective) channel. Erosion of sediment from the bottom and sides of this channel is to be expected. One way the sediment load could be reduced would be to construct a settling pond at or near the point of discharge of the creek from the mine area, giving the sediment a chance to settle out. An alternative method might be to construct small barriers within the channel to create small bodies of standing water and thereby allow some sediment to settle. A settling pond would be more effective, but would present a considerable problem because the drainage area of the creek is large enough to have considerable flow at times.

Values of 40 mg/L daily maximum and 35 and 30 mg/L 30 day maximum values for suspended solids cannot be met at the mine with current practices, either for the settling ponds or for the mine efflunt.

3 HEALTH AND ENVIRONMENTAL IMPACTS

3.1 SURFACE WATER

At Mine IL-1, the only treatment of the water is the system of settling ponds, two of which were examined in succession during the course of the project. The first pond was small, and the suspended sediment frequently exceeded 50 mg/L. (This figure is mentioned because it is the standard currently set by Illinois for mine effluent). By this standard, the first pond was not very effective. The second pond, on the other hand, is much more effective and can generally produce water with less than 35 mg/L suspended solids, a value currently under consideration for adoption by the state of Illinois.

The drainage diversion ditch which takes the creek around the mine is itself a probable source of suspended sediment. Its steep banks are more subject to erosion than a natural stream, and gullying on the sides attests to the fact that sediment is being washed into the channel. At the time this project was ending, plans were being made to move the creek once again, this time into the mined area close to its original position. This move will shorten the stream length and may give the channel a more natural shape, but it will also provide opportunity for continued erosion of material into the stream.

At the point where the creek leaves the main part of the mine, suspended solids were frequently higher than 50 mg/L. Ample opportunity has existed in the past for the stream to pick up materials from pit pumpage and/or erosion of the channel. Similar opportunities are likely to exist in the future. One way to solve the problem of high suspended solids would be to have one or more settling ponds on the stream itself, with one close to the point of discharge from the mine property. If more stringent standards are adopted, something like this will probably be imperative unless the mine is granted a variance.

The other environmental impact the mine has and will continue to have is in the area of water quality. Water draining from the mined area will show the effects of interaction with the overburden rocks and will contain those materials it picks up from the rocks. The quality of the water is likely to be similar to that currently in the creek after it has received the mine contribution. Based on these data, water below the mine ought to contain about the following values:

Total dissolved solids:	2700 mg/L average; range 400 to 6100 mg/L.
Sulfate:	1450 mg/L average; range 200 to 3600 mg/L.
Sodium:	830 mg/L average; range 60 to 2150 mg/L.

This water will not be particularly harmful, but the high concentrations of these three parameters should make it unsuitable for drinking water and of somewhat limited usefulness for such applications as stock watering or irrigation. In connection with the latter application, the water was used during the summer of 1977 for watering a crop planted on recently reclaimed mine-spoil materials, with relatively good results. Continued use of the water could result in build-up of salts and eventually decrease productivity. In the climate of southwestern Illinois, where rainfall exceeds evaporation, this would take many years, however, and the water can be used provided the crops involved have relatively high sodium tolerance.

3.2 GROUNDWATER

The mine is unlikely to have a direct effect on aquifers because there are no important ones in the area, and the sandstone of the lower Pennsylvanian and upper Mississippian sections are separated from the mining activity by several hundred feet of sedimentary rock.

The one important effect the mine will have is to act as a groundwater reservoir itself and thereby improve the base flow of the creek. The spoil material is loose and has a high porosity and permeability. Water can infiltrate into the spoil fairly easily, and the mined area thereby acts like an enormous sponge, soaking up rainfall to release it slowly later on. This has the effect of dumping the extremes of flow of the associated streams by decreasing the peak discharge after precipitation and increasing base flow in dry weather.

It should be pointed out that this relatively beneficial aspect of surface mining may not exist in the future. Mining laws require grading, and topsoil replacement of the mined area requires that heavy machinery be moved across the surface of the spoil. This movement results in compaction of the near-surface materials, greatly reducing the infiltration properties.

APPENDIXES*

*The tables and graphs in Appendixes E and F are reproduced as received by Argonne from the author, with no enhancement of the camera-ready copy.

Appendix A

Analytical Procedure for Overburden

Digestion. The digestion procedure used was that of Shapiro and Brannock (1952), modified slightly to provide higher concentrations of material in solution.

a. In a Teflon crucible, weigh approximately 0.50 g of sample to the nearest 0.1 mg.

b. Under a fume hood, add 10 mL of acid mixture and swirl to wet the sample.

c. Place the crucible on a hotplate and heat until SO_2 fumes begin to evolve.

d. Remove from heat, add 20 mL of distilled deionized water, and reheat, swirling occasionally until material dissolves.

e. Transfer to 100-mL volumetric flask and dilute to volume with distilled deionized water.

f. Transfer to clean polyethylene bottle for storage.

Reagent. Acid mixture: 200 mL HF (48%), 66 mL H_2SO_4 (concentrated), and 16 mL HNO_3 (concentrated). Under a fume hood, transfer the HF to a 1-L polyethylene bottle. Add the H_2SO_4 and allow to cool. Add the HNO_3 and mix.

Analysis. Analyses were made by standard atomic absorption techniques except for mercury, which was done by a flameless atomic absorption technique.

Working curves, except for mercury, were made at 1, 2, 5, and 10 mg/L with acid-spiked standard solutions. Unknowns were compared directly with the curves. Dilutions, where necessary, were made with distilled deionized water. For samples with values of less than 1 ppm, the signal was amplified until the 1-ppm standard registered 1000 on the instrument readout; the sample was then reanalyzed.

Mercury was analyzed with a 25-mL portion of the dissolved sample solution, run as if it were a water sample Standard solutions in this case did not exceed 20 ppb, and samples were reanalyzed using smaller amounts of sample if the value exceeded this amount.

Estimated detection limits (ppm)

Fe	1	Cr	1
Mn	1	Cu	1
Zn	1	Pb	1
Cd	0.2	Ni	1
Co	1	Hg	0.005

Appendix A

Analytical Procedure for Overburden

Digestion. The digestion procedure used was that of Shapiro and Brannock (1956), modified slightly to provide higher concentrations of material in solution.

a. In a Teflon crucible, weigh approximately 0.20 g of sample to the nearest 0.1 mg.

b. Under a fume hood, add 15 ml of acid mixture and swirl to wet the sample.

c. Place the crucible on a hotplate and heat until SO_3 fumes begin to evolve.

d. Remove from heat, add 20 ml of distilled deionized water, and reheat, swirling occasionally until material dissolves.

e. Transfer to 100-ml volumetric flask and dilute to volume with distilled deionized water.

f. Transfer to clean polyethylene bottle for storage.

Reagent. Acid mixture: 500 ml HF (48%), 50 ml H_2SO_4 (concentrated), and 10 ml HNO_3 (concentrated). Under a fume hood, transfer the HF to a 1-L polyethylene bottle. Add the H_2SO_4 and allow to cool. Add the HNO_3 and mix.

Analysis. Analyses were made by standard atomic absorption techniques except for mercury, which was done by a flameless atomic absorption technique.

Working curves, except for mercury, were made at 1, 2, 5, and 10 mg/L with acid-spiked standard solutions. Unknowns were compared directly with the curves. Dilutions, where necessary, were made with distilled deionized water. For samples with values of less than 1 ppm, the signal was amplified until the 1-ppm standard registered 1000 on the instrument readout; the sample was then reanalyzed.

Mercury was analyzed with a 10-ml portion of the dissolved sample solution, run as if it were a water sample. Standard solutions in this case did not exceed 20 ppb, and samples were reanalyzed using smaller amounts of sample if the value exceeded this amount.

Estimated detection limits (ppm)

[illegible]	1	Cr	1
[illegible]	1	Cu	1
[illegible]	1	[illegible]	1
[illegible]	0.2	[illegible]	1
[illegible]	1	[illegible]	0.005

Appendix B

Coal Analyses

A 1-g sample of coal was weighed to the nearest 0.1 mg in a porcelain crucible and covered with a loose-fitting lid. The covered crucible was placed in a furnace and heated slowly to 600°C to oxidize the organic fraction of the coal. The crucibles were allowed to cool, after which the ash was transferred to a Teflon beaker. From this point on, the sample was treated like overburden material.

Appendix C

Water Collection and Handling

Bottles. One 1000-mL bottle and one 500-mL bottle were used for each station. The bottles were rinsed and acid soaked to remove any adsorbed ions or precipitates. Subsequently, they were washed with Alcanox and rinsed with tap water, then distilled water and finally distilled deionized water. After air drying, they were capped until ready for field use.

Collection. Samples were collected as close to the midpoint of flow and mid-depth as practical. Two samples were taken at each site, one untreated and one acidified. The untreated sample was filled as full as possible and then tightly capped. The acidified sample was not completely filled, to prevent loss of the acid. Care was taken not to disturb the bottom sediment at the point of sample collection.

Preservation. The only preservation used was 2 mL of concentrated HNO_3 in the 500 mL bottle to preserve metals.

Handling. The collection and analysis scheme was designed so that water samples were returned to the lab and analysis of critical parameters (pH, acidity, alkalinity, etc.) begun within four hours of collection (and often less).

Flow measurements. A cross section of each sample location was constructed at the time the first set of flow measurements were taken. In streams, flows were measured at mid-depth and mid-stream with a current meter which measured velocity in feet per second. Water depths were measured at mid-stream and used, in connection with the measured profile, to determine stream cross-section area.

Appendix C

Water Collection and Handling

Bottles. One 1000-ml bottle and one 500-ml bottle were used for each station. The bottles were rinsed and acid soaked [illegible] remove any adsorbed ions or precipitations. Subsequently, they were washed with Alconox and rinsed with tap water, then distilled water and finally distilled deionized water. After air drying, they were capped until ready for field use.

Collection. Samples were collected as close to the midpoint of flow mid-channel as practical. Two samples were taken at each site, one unacidified and one acidified. The unacidified sample was filled as full as possible and then tightly capped. The acidified sample was not completely filled, to prevent loss of the acid. Care was taken not to disturb the bottom sediment at the point of sample collection.

Preservation. The only preservation used was 2 ml of concentrated HNO_3 in the 500 ml bottle to preserve metals.

Handling. The collection and analysis scheme was designed so that water samples were returned to the lab and analyses of critical parameters (pH, acidity, alkalinity, etc.) begun within four hours of collection (and [illegible]).

Flow measurements. A cross section of each sample location was constructed [illegible] the first set of flow measurements were taken. In stream, flows were measured at mid-depth and mid-stream with a current meter which measured velocity in feet per second. Water depths were measured at mid-stream and [illegible] in connection with the measured profile to determine [illegible] cross section area.

Appendix D

Analytical Procedures for Water

All analyses except those for ammonia and mercury were done according to Standard Methods (1971).

Filtration. Filtration was done in the laboratory with Reeves-Angel glass-fiber filter paper. Filtration was generally completed within two to five hours after collection of the sample and after alkalinity and acidity titrations were completed for the sample.

Ammonia. Analysis was done with an Orion ammonia-sensitive electrode. Standards were prepared at 0.01, 0.1, 1, and 10 mg/L NH_3 (U.S. Environmental Protection Agency, 1979).

Fluoride. Analysis was done with an Orion solid-state, fluoride-sensitive electrode. Hach total ionic strength buffer was added to the sample and standards to adjust pH, complex interfacing ions, and ionic strength.

Total Dissolved Solids. Analysis was done by evaporation of known volume (100 mL) of solution and drying of residue at 105°C.

Total Suspended Solids. Analysis was done by vacuum filtration of 250 mL of sample through Reeves-Angel glass fiber filter paper, followed by drying of the residue at 105°C and weighing.

Alkalinity. Analysis was done by potentiometric titration, as soon as possible after opening the sample bottle.

Acidity. Analysis was done by potentiometric titration, as soon as possible after alkalinity analysis. The bottle was opened, the sample extracted and run for alkalinity; then the bottle was reopened and analyzed for acidity. Standard titrant was protected from atmospheric CO_2 by an Ascarite scrubber tube. Titration end point was 8.3.

Total Iron. Analysis was done by atomic absorption (AA) spectrohotometry on the acidified sample. Analyses were done in triplicate, and the average value was used. Dilutions, when necessary, were with distilled deionized water.

Ca, Mn, Al, Cu, and Zn. These metals were determined by standard AA spectrophotometry on a Perkin-Elmer Model 107 AA spectrophotometer. Dilutions. when necessary, were with distilled deionized water.

Sodium and Strontium. These elements were determined with a Perkin-Elmer AA spectrophotometer operating in the flame-emission mode.

Cd, Co, Cr, Ni, and Pb. These elements were pre-concentrated before analysis by chelation with ammonium pyrrolidine dithiocarbamate and extraction into methyl isobutyl ketone. Standard solutions were similarly treated. A Perkin-Elmer Model 107 AA spectrophotometer was adjusted to provide for an organic solvent, and the metals were determined by AA spectrophotometry.

Mercury. This element was determined by flameless AA cold vapor technique with the Perkin-Elmer Mercury Analysis System. Analysis was similar in design to that described in U.S. Environmental Protection Agency (1979).

Appendix E

Water Quality Data

Mine Name (and/or code) ______________________ Date 4/29/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2										
pH (field)	7.16	7.58	7.40	7.42	7.79	7.40	6.71	6.08		
pH (lab)	7.20	7.61	7.63	7.69	7.73	7.80	7.36	4.70		
Temp. (H_2O)										
Temp. (air)										
Cond.	3273	2920	3072	2357	614	1400	2910	2800		
Ammonia-N	0.02	0.02	0.01	0.06	0.03	0.01	4.37	2.88		
Chloride	9.0	9.0	10.0	10.0	10.0	11.0	14.0	8.5		
Fluoride	0.12	0.11	0.12	0.08	0.02	0.05	0.20	0.16		
Sulfate	2479	2164	2319	1560	220	735	2139	2160		
TD Solids	3902	3497	3479	2384	420	1205	3102	3086		
TS Solids	53	56	23	8	8	44	71,983	46		
Alkalinity	377	277	272	217	94	150	628	5		
Acidity	108	73	72	47	27	21	46	55		
Total Fe	0.87	0.30	0.17	0.53	0.15	0.75	0.24	0.45		
Diss. Fe										
" Ca	238	219	214	171	37.1	109	232	241		
" Mg										
" Na	92.4	83.6	101	132	40.7	133	210	132		
" K										
" Mn	1.40	0.27	0.45	0.14	0.03	0.13	10.4	19.97		
" Al	0.6	0.4	0.4	0.9	0.6	0.8	0.3	0.9		
" Cu	0.04	0.04	0.04	0.02	0.02	0.02	0.04	0.04		
" Zn	0.03	0.00	0.00	0.00	0.00	0.01	0.04	0.41		
" Sr	2.14	1.88	1.91	1.40	0.13	0.74	2.41	1.44		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 5/12/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108
	Sampling Sites							
Flow, cfs								
Diss. O_2	8.6	6.1	9.4	9.0	4.3	7.3		5.5
pH (field)	7.10	7.60	7.50	7.50	7.40	7.30	7.10	5.00
pH (lab)	7.02	7.43	7.55	7.51	7.62	7.28	7.26	4.65
Temp. (H_2O)	16	17	16	17	15	15	15	12
Temp. (air)								
Cond.	3434	3253	3213	2699	701	1581	3626	3001
Ammonia-N	0.11	0.01	0.01	0.01	0.01	0.01	3.62	2.55
Chloride	10	11	11	11	11	12	13	4.4
Fluoride	0.14	0.09	0.07	0.09	0.18	0.04	0.12	0.18
Sulfate	2677	2422	2303	1762	261	735	2332	2211
TD Solids	4400	3850	3701	2851	526	1278	3450	2925
TS Solids	23	30	16	21	9	20	58,466	31
Alkalinity	373	269	263	227	112	163	352	0
Acidity	150	90	83	60	14	25	55	65
Total Fe	0.29	0.00	0.00	0.11	0.03	0.46	0.09	0.24
Diss. Fe								
" Ca	257	233	227	192	46.0	73.3	376	246
" Mg								
" Na	96.8	91.3	92.4	102	42.9	132	133	132
" K								
" Mn	0.52	0.03	0.09	0.13	0.04	0.20	9.05	20.40
" Al	0.2	0.3	0.1	0.1	0.1	0.2	0.2	0.6
" Cu	0.04	0.04	0.04	0.04	0.02	0.02	0.04	0.04
" Zn	0.02	0.05	0.01	0.01	0.00	0.00	0.04	0.34
" Sr	2.44	2.10	1.86	1.56	0.11	0.53	1.13	0.91
" Cd								
" Co								
" Cr								
" V								
" Mo								
" Ni								
" Pb								
" Hg								

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 5/24/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	8.0	7.6	8.4	8.2	8.5	7.5		8.3		
pH (field)	7.05	7.30	7.45	7.50	7.25	7.40	7.10	5.05		
pH (lab)	7.21	7.48	7.69	7.67	7.82	7.51	7.32	5.62		
Temp. (H_2O)	16	17	20	18	17	20	23	19		
Temp. (air)										
Cond.	3864	3545	3280	2465	684	1563	3434	3137		
Ammonia-N	0.06	0.06	0.00	0.02	0.00	0.03	3.44	8.81		
Chloride	10	10	10	10	11	11	14	7.0		
Fluoride	0.32	0.32	0.29	0.19	0.06	0.10	0.10	0.32		
Sulfate	2706	2399	2290	1408	226	731	2367	2138		
TD Solids	4302	3756	3559	2210	460	1228	3392	3099		
TS Solids	41	48	20	32	12	67	77,051	17		
Alkalinity	327	270	253	226	109	162	469	2		
Acidity	108	47	43	43	15	30	49	51		
Total Fe	1.10	0.54	0.25	0.60	0.38	1.25	4.95	0.19		
Diss. Fe										
" Ca	256	238	223	172	44.6	112	246	242		
" Mg										
" Na	78.1	92.4	92.4	132	46.2	122	231	122		
" K										
" Mn	2.44	0.45	0.21	0.32	0.08	0.39	13.57	18.30		
" Al	0.2	0.7	0.3	0.9	1.1	1.6	4.6	0.3		
" Cu	0.00	0.02	0.04	0.02	0.00	0.00	0.07	0.02		
" Zn	0.02	0.03	0.02	0.01	0.02	0.01	0.04	0.30		
" Sr	2.71	2.21	2.21	1.50	0.23	0.95	3.09	1.87		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 6/7/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	7.4	6.7	9.7	8.3	9.2	6.9		9.1		
pH (field)	6.95	7.45	7.30	7.25	7.30	7.15	6.85	6.20		
pH (lab)	7.60	8.00	7.90	7.95	8.15	7.60	7.60	5.70		
Temp. (H_2O)	21	23	25	23	20	23	27	26		
Temp. (air)										
Cond.	3848	2983	3361	1790	681	1591	3231	3082		
Ammonia-N	0.86	0.94	0.36	0.08	0.08	0.09	3.81	2.27		
Chloride	9	10	14	13	11	14	11	9.9		
Fluoride	0.37	0.28	0.31	0.23	0.11	0.30	0.52	0.49		
Sulfate	2627	2093	2381	900	217	676	2300	2226		
TD Solids	4247	3342	3839	1574	460	1213	3464	3323		
TS Solids	26	41	39	58	14	47	68,806	18		
Alkalinity	337	262	300	225	122	225	47	19		
Acidity	100	62	56	36	8	26	14	30		
Total Fe	1.42	0.27	0.29	0.71	0.13	0.78	0.27	0.20		
Diss. Fe										
" Ca	157	138	145	126	37.2	108	165	155		
" Mg										
" Na	111	96.6	125	123	42.2	123	139	132		
" K										
" Mn	2.11	0.20	0.05	0.71	0.02	0.84	11.18	8.87		
" Al	0.35	0.20	0.88	0.76	0.74	0.99	0.02	0.51		
" Cu	0.06	0.00	0.00	0.03	0.04	0.02	0.03	0.01		
" Zn	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.30		
" Sr	2.50	1.30	2.17	0.94	0.13	0.78	2.07	1.72		
" Cd	0.027	0.011	0.022	0.023	0.010	0.009	0.034	0.011		
" Co	0.08	0.01	0.04	0.04	0.00	0.02	0.06	0.11		
" Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
" V										
" Mo										
" Ni	0.07	0.08	0.04	0.00	0.08	0.03	0.14	0.30		
" Pb	0.01	0.03	0.02	0.07	0.08	0.01	0.05	0.16		
" Hg	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000		

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 6/22/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs					DRY	DRY				
Diss. O_2	8.4	9.2	10.2	10.0				8.4		
pH (field)	7.30	7.65	7.60	7.70			7.30	6.80		
pH (lab)	7.28	7.70	7.74	8.01			7.33	6.76		
Temp. (H_2O)	26	27	27	28			27	26		
Temp. (air)										
Cond.	3668	3441	3549	3353			3137	3245		
Ammonia-N	0.94	0.09	0.11	0.09			5.81	3.52		
Chloride	9	9	15	15			13	11		
Fluoride	0.37	0.24	0.23	0.21			0.23	0.43		
Sulfate	2264	2594	2541	2277			2277	2255		
TD Solids	3468	4127	3850	3463			3548	2935		
TS Solids	31	31	70	21			79,394	22		
Alkalinity	357	217	251	222			408	20		
Acidity	74	31	20	17			22	23		
Total Fe	0.41	0.05	0.05	0.09			0.00	0.29		
Diss. Fe										
" Ca	87.2	81.8	83.7	81.1			86.3	84.1		
" Mg										
" Na	102	94.8	110	112			130	118		
" K										
" Mn	1.26	0.13	0.00	0.09			10.13	12.31		
" Al	0.44	0.27	0.14	0.66			0.60	0.60		
" Cu	0.03	0.03	0.01	0.03			0.02	0.02		
" Zn	0.00	0.00	0.00	0.00			0.01	0.15		
" Sr	2.26	1.83	1.82	1.82			2.13	1.51		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 7/6/76

Values in mg/l (except cond., pH, flow, and temp.).

	Sampling Sites							
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108
Flow, cfs								
Diss. O_2	7.6	10.4	7.7	7.6	8.4	7.2		6.9
pH (field)	7.41	7.75	7.62	7.60	7.60	7.38	6.50	6.70
pH (lab)	7.71	8.08	8.17	8.01	7.96	7.84	6.55	6.53
Temp. (H_2O)	26	26	27	28	24	27	28	27
Temp. (air)								
Cond.	3470	2068	2018	1621	539	1018	3072	1710
Ammonia-N	0.05	0.01	0.01	0.01	0.01	0.01	3.98	2.47
Chloride	10	8	10	10	11	9.0	13	7.8
Fluoride	0.26	0.24	0.24	0.20	0.09	0.13	0.25	0.26
Sulfate	2281	1216	1262	891	177	462	2238	1100
TD Solids	3638	1917	1979	1401	346	725	3346	1572
TS Solids	39	26	15	25	6	33	30.009	17
Alkalinity	308	176	146	131	101	111	90	21
Acidity	31	6	5	7	6	6	81	25
Total Fe	1.26	0.29	0.03	0.34	0.32	1.23	0.41	5.61
Diss. Fe								
" Ca	100	72.7	70.8	59.9	26.6	38.7	96.3	61.6
" Mg								
" Na	84.9	50.9	44.3	60.5	33.6	72.5	120	46.7
" K								
" Mn	1.40	0.30	0.17	0.09	0.01	0.06	19.21	9.10
" Al	0.41	0.65	0.52	0.57	0.85	0.82	0.87	0.65
" Cu	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.02
" Zn	0.02	0.00	0.01	0.01	0.00	0.00	0.05	0.15
" Sr	2.91	1.47	1.58	1.32	0.24	0.80	2.55	1.00
" Cd								
" Co								
" Cr								
" V								
" Mo								
" Ni								
" Pb								
" Hg								

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 7/20/76

Values in mg/l (except cond., pH, flow, and temp.)

Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	8.2	8.9	7.1	7.4	8.7	7.7		7.2		
pH (field)	7.40	7.75	7.50	7.45	7.90	7.35	5.55	6.45		
pH (lab)	7.48	8.12	8.21	8.18	8.41	7.99	4.48	6.60		
Temp. (H_2O)	30	32	32	32	29	31	31	31		
Temp. (air)										
Cond.	3497	3001	2693	2207	684	1362	4030	2620		
Ammonia-N	0.09	0.04	0.01	0.03	0.86	0.47	2.52	2.90		
Chloride	14	14	13	14	15	14	17	13		
Fluoride	0.37	0.32	0.41	0.37	0.28	0.21	1.13	0.51		
Sulfate	2502	2060	1711	1309	223	596	2925	1723		
TD Solids	4147	3440	2772	2172	475	1078	4458	2649		
TS Solids	26	26	12	11	5	4	1158	18		
Alkalinity	367	268	208	181	122	107	0	11		
Acidity	36	14	7	8	0	14	181	35		
Total Fe	0.82	0.18	0.05	0.08	0.09	0.10	14.42	0.21		
Diss. Fe										
" Ca	52.4	46.6	42.9	39.0	17.0	26.2	55.0	46.6		
" Mg										
" Na	81.7	74.4	55.7	80.2	46.5	105	115	80.5		
" K										
" Mn	1.46	0.18	0.03	0.05	0.03	0.03	29.89	14.37		
" Al	0.06	0.06	0.06	0.06	0.06	0.06	4.50	0.06		
" Cu	0.01	0.03	0.02	0.01	0.00	0.01	0.03	0.03		
" Zn	0.01	0.01	0.01	0.01	0.01	0.01	1.01	0.19		
" Sr	3.01	2.36	1.97	1.56	0.24	0.92	1.94	1.52		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 8/3/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

Parameter	Sampling Sites H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	8.2	10.2	7.9	8.1	8.9	7.6	7.1	8.2		
pH (field)	7.30	7.90	7.60	7.60	7.80	7.60	5.40	6.80		
pH (lab)	7.55	8.18	8.16	8.08	7.95	7.93	4.68	7.32		
Temp. (H_2O)	26	28	28	26	27	28	34	29		
Temp. (air)										
Cond.	3296	2207	2997	2197	393	1353	3951	2650		
Ammonia-N	0.01	0.01	0.01	0.01	0.01	0.01	0.98	0.01		
Chloride	15	14	16	14	10	13	12	13		
Fluoride	0.31	0.40	0.32	0.25	0.14	0.18	1.07	0.54		
Sulfate	2116	1299	1916	1250	107	610	2935	1779		
TD Solids	3616	2085	3050	2046	258	1035	4404	2660		
TS Solids	40	26	15	21	12	17	41	15		
Alkalinity	351	226	221	192	118	136	5	23		
Acidity	48	3	5	7	15	9	173	18		
Total Fe	0.77	0.06	0.10	0.10	0.38	0.25	52.34	1.34		
Diss. Fe										
" Ca	119	102	117	98.1	26.5	73.9	130	124		
" Mg										
" Na	99.9	56.3	82.4	105	19.2	109	122	83.1		
" K										
" Mn	0.81	0.16	0.09	0.05	0.01	0.01	29.10	16.26		
" Al	0.39	0.17	0.15	0.24	0.68	0.32	3.54	0.15		
" Cu	0.01	0.00	0.01	0.00	0.00	0.02	0.00	0.00		
" Zn	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.16		
" Sr	2.57	1.62	2.29	1.61	0.14	0.92	2.13	1.52		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) __________ Date 8/17/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
	Sampling Sites									
Flow, cfs							DRY			
Diss. O_2	9.5	11.4	8.3	8.1	8.6	8.0		8.9		
pH (field)	7.20	7.70	7.40	7.50	7.30	7.50		6.80		
pH (lab)	7.31	8.02	7.92	7.83	7.91	7.72		7.04		
Temp. (H_2O)	26	28	27	27	24	27		28		
Temp. (air)										
Cond.	3367	2152	2389	1757	337	1292		2676		
Ammonia-N	0.02	0.01	0.01	0.01	0.01	0.01		1.22		
Chloride	14	9	15	14	10	14		12		
Fluoride	0.31	0.23	0.22	0.16	0.12	0.12		0.31		
Sulfate	2298	1244	1618	954	65	581		1883		
TD Solids	3899	2112	2724	1701	229	1068		2881		
TS Solids	36	40	26	36	26	101		21		
Alkalinity	318	171	228	150	107	130		30		
Acidity	68	10	14	13	8	17		27		
Total Fe	0.72	0.14	0.07	0.19	0.83	0.75		0.35		
Diss. Fe										
" Ca	77.2	57.1	62.7	50.1	14.8	39.7		71.8		
" Mg										
" Na	89.1	69.4	76.3	85.8	22.3	93.9		84.5		
" K										
" Mn	1.38	0.13	0.07	0.09	0.07	0.07		15.34		
" Al	0.21	0.26	0.16	0.52	1.10	1.49		0.16		
" Cu	0.02	0.02	0.02	0.01	0.01	0.02		0.01		
" Zn	0.01	0.01	0.01	0.01	0.01	0.01		0.21		
" Sr	2.76	1.39	1.88	1.16	0.09	0.82		1.42		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 8/30/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	9.3	8.8	8.5	10.0	13.8	10.2		9.1		
pH (field)	7.20	7.50	7.50	7.60	8.00	7.70	7.00	6.90		
pH (lab)	7.32	7.87	7.89	7.95	8.28	7.88	7.26	7.17		
Temp. (H_2O)	25.5	26	28	28	29	27	28	28		
Temp. (air)										
Cond.	3778	2973	2883	1988	864	1511	3331	2863		
Ammonia-N	0.01	0.01	0.02	0.01	0.01	0.01	3.96	3.02		
Chloride	14.90	14.04	12.33	13.64	13.91	14.27	14.40	14.76		
Fluoride	0.36	0.32	0.31	0.26	0.28	0.18	0.52	0.47		
Sulfate	2668	1942	1858	1096	356	696	2472	2105		
TD Solids	4556	3031	2873	1723	617	1166	3750	3114		
TS Solids	33	19	27	21	6	31	48,537	17		
Alkalinity	355	217	208	134	86	139	151	18		
Acidity	59	23	19	13	2	11	36	19		
Total Fe	0.58	0.14	0.04	0.22	0.08	0.40	155.57	0.23		
Diss. Fe										
" Ca	57.4	58.0	58.0	45.3	35.9	38.3	70.1	67.4		
" Mg										
" Na	109	79.8	79.0	106	31.5	113	119	89.0		
" K										
" Mn	1.47	0.09	0.03	0.03	0.02	0.02	17.40	14.07		
" Al	0.81	0.07	0.07	0.07	0.07	0.98	0.71	0.39		
" Cu	0.02	0.02	0.02	0.00	0.01	0.02	0.02	0.01		
" Zn	0.00	0.01	0.01	0.00	0.01	0.00	0.02	0.17		
" Sr	2.99	2.09	1.98	1.26	0.45	0.86	2.18	1.55		
" Cd	0.020	0.008	0.016	0.015	0.012	0.012	0.093	0.051		
" Co	0.01	0.01	0.01	0.01	0.01	0.01	0.14	0.11		
" Cr	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
" V										
" Mo										
" Ni	0.16	0.47	0.18	0.21	0.21	0.11	0.34	0.61		
" Pb	0.01	0.03	0.00	0.03	0.00	0.02	0.03	0.00		
" Hg	0.0003	0.0002	0.0004	0.0001	0.0002	0.0001	0.0002	0.0003		

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________ Date 9/14/76

Values in mg/l (except cond., pH, flow, and temp.)

	Sampling Sites									
	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Parameter										
Flow; cfs					DRY					
Diss. O_2	8.0	8.5	7.7	8.7		8.3		8.4		
pH (field)	7.2	7.5	7.6	7.7		7.8	6.5	6.9		
pH (lab)	7.33	7.89	7.98	8.01		7.97	5.78	7.41		
Temp. (H_2O)	25	25	28	27		27	27	27		
Temp. (air)										
Cond.	3669	3158	2922	2298		1631	3196	2931		
Ammonia-N	0.03	0.01	0.01	0.01		0.01	1.62	1.76		
Chloride	15.66	15.84	14.36	18.99		18.05	20.21	16.20		
Fluoride	0.54	0.45	0.44	0.37		0.26	0.73	0.66		
Sulfate	2599	2227	1980	1465		801	2870	2200		
TD Solids	4421	3634	3174	2335		1332	4151	3273		
TS Solids	23	34	22	21		94	918	19		
Alkalinity	289	254	232	194		163	22	17		
Acidity	36	20	17	11		13	59	19		
Total Fe	0.36	0.08	0.03	0.07		0.09	15.47	0.30		
Diss. Fe										
" Ca	82.2	72.5	66.0	54.5		35.6	55.8	41.6		
" Mg										
" Na	111	106	99.5	137		204	145.8	117		
" K										
" Mn	1.49	0.39	0.16	0.07		0.04	29.03	19.27		
" Al	0.25	0.08	0.05	0.22		0.15	1.07	0.10		
" Cu	0.02	0.03	0.02	0.01		0.01	0.03	0.02		
" Zn	0.01	0.01	0.01	0.01		0.01	0.73	0.15		
" Sr	3.44	2.74	2.35	1.84		1.19	2.17	1.92		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 9/28/76

Values in mg/l (except cond., pH, flow, and temp.)

	Sampling Sites							
	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108
Parameter					DRY			
Flow, cfs								
Diss. O_2	9.4	11.1	9.2	9.9		10.0		9.0
pH (field)	6.8	7.5	6.5	7.3		7.0	6.5	6.5
pH (lab)	7.48	8.02	8.06	8.08		8.11	7.66	6.91
Temp. (H_2O)	21	22	22	22		21	23	24
Temp. (air)								
Cond.	3727	3378	3080	2505		1726	2988	2967
Ammonia-N	0.01	0.01	0.01	0.01		0.01	4.66	3.48
Chloride	17.9	16.6	16.3	15.9		18.5	18.3	13.6
Fluoride	0.35	0.33	0.36	0.28		0.19	0.36	0.52
Sulfate	2548	2313	1995	1516		844	2342	2181
TD Solids	4311	3771	3447	2536		1516	3579	3637
TS Solids	62	24	46	16		68	44.607	17
Alkalinity	365	287	279	199		170	246	24
Acidity	39	25	13	12		7	23	16
Total Fe	0.66	0.17	0.09	0.09		0.11	0.09	1.03
Diss. Fe								
" Ca	105	98.4	94.2	83.5		66.1	105	103
" Mg								
" Na	109	104	97.1	126		169	184	121
" K								
" Mn	1.58	0.38	0.20	0.13		0.04	20.28	20.09
" Al	0.25	0.03	0.76	0.15		0.25	0.03	0.05
" Cu	0.01	0.01	0.00	0.00		0.00	0.00	0.01
" Zn	0.01	0.01	0.02	0.01		0.01	0.04	0.16
" Sr	3.54	3.08	2.53	2.04		1.38	3.52	2.03
" Cd								
" Co								
" Cr								
" V								
" Mo								
" Ni								
" Pb								
" Hg								

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 10/12/76

Values in mg/l (except cond., pH, flow, and temp.)

Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs					DRY					
Diss. O_2	8.4	7.3	11.0	9.1		8.5		8.5		
pH (field)	7.10	7.50	7.40	7.10		7.10	6.8	6.80		
pH (lab)	7.68	7.95	8.25	8.05		8.12	7.58	6.88		
Temp. (H_2O)	22	23	27	22		22	22	21		
Temp. (air)										
Cond.	3628	3431	3186	1961		1941	3333	3088		
Ammonia-N	0.16	0.05	0.02	0.01		0.01	4.12	2.04		
Chloride	13.7	15.3	16.8	21.1		19.5	21.7	14.6		
Fluoride	0.54	0.48	0.44	0.31		0.29	0.37	0.69		
Sulfate	2695	2554	2261	1022		841	2527	2352		
TD Solids	4570	3969	3601	1653		1556	3744	3419		
TS Solids	27	26	12	13		12	150,239	96		
Alkalinity	395	276	220	183		192	223	59		
Acidity	36	19	2	7		5	36	22		
Total Fe	0.44	0.10	0.05	0.22		0.15	0.08	1.35		
Diss. Fe										
" Ca	87.3	84.2	79.1	56.6		57.5	89.4	86.7		
" Mg										
" Na	115	109	222	180		185	202	123		
" K										
" Mn	1.48	0.16	0.08	0.16		0.03	13.99	19.09		
" Al	0.22	0.04	0.10	0.08		0.05	0.05	0.12		
" Cu	0.01	0.02	0.01	0.01		0.01	0.03	0.01		
" Zn	0.03	0.01	0.01	0.00		0.00	0.03	0.14		
" Sr	3.53	3.15	2.64	1.55		1.51	3.56	2.15		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 10/25/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	8.9	10.4	10.9	8.9	7.2	9.5	9.3	9.6		
pH (field)	6.70	7.00	7.20	7.40	7.40	6.80	6.40	6.40		
pH (lab)	7.44	7.86	7.77	7.73	7.62	7.68	6.79	7.02		
Temp. (H_2O)	14	13	12	13	12	12	12.5	13		
Temp. (air)										
Cond.	2944	2780	2966	1435	274	1312	3086	2747		
Ammonia-N	0.01	0.01	0.01	0.01	0.01	0.01	1.18	1.82		
Chloride	13.3	14.4	20.2	9.5	11.2	29.7	15.6	13.5		
Fluoride	0.56	0.59	0.44	0.26	0.20	0.17	0.60	0.69		
Sulfate	2308	2058	2203	769	108	673	2533	2107		
TD Solids	3898	3384	3641	1297	265	1114	3624	3244		
TS Solids	27	27	24	24	120	19	35	20		
Alkalinity	338	234	264	155	48	148	28	18		
Acidity	48	22	45	12	11	16	54	26		
Total Fe	0.67	0.01	0.08	0.36	11.22	0.24	9.05	1.86		
Diss. Fe										
" Ca	84.6	79.3	82.9	54.0	12.0	50.4	87.0	87.4		
" Mg										
" Na	128	81.7	120	127	25.2	127	122	114		
" K										
" Mn	1.68	0.15	0.20	0.04	0.10	0.04	21.35	17.82		
" Al	0.28	0.50	0.08	0.17	5.25	0.14	0.19	1.76		
" Cu	0.02	0.01	0.02	0.00	0.01	0.01	0.01	0.02		
" Zn	0.01	0.01	0.01	0.01	0.02	0.01	0.39	0.18		
" Sr	2.90	2.50	2.47	0.99	0.07	0.89	1.90	1.98		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 11/8/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

Parameter	Sampling Sites H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	9.2	11.6	9.9	10.9	8.2	9.3	9.5	9.4		
pH (field)	7.30	7.70	7.40	7.60	7.60	7.60	7.00	6.90		
pH (lab)	7.31	7.83	7.67	7.78	7.49	7.69	7.36	7.24		
Temp. (H_2O)	12	12	11	11	10	11	10	11		
Temp. (air)										
Cond.	2960	2635	2845	2309	472	1459	2320	2341		
Ammonia-N	0.05	0.04	0.03	0.03	0.02	0.05	1.78	2.22		
Chloride	13.3	15.3	25.3	26.0	11.1	30.6	12.0	14.8		
Fluoride	0.71	0.62	0.54	0.48	0.39	0.26	0.96	1.13		
Sulfate	2603	2309	2532	1981	158	885	2327	2248		
TD Solids	4291	3746	4016	3158	319	1430	3492	3349		
TS Solids	41	30	24	16	52	14	298	22		
Alkalinity	348	256	307	271	125	187	217	16		
Acidity	75	30	66	38	13	30	35	21		
Total Fe	0.62	0.09	0.02	0.09	0.91	0.11	0.07	0.79		
Diss. Fe										
" Ca	88.8	82.5	87.5	67.9	23.8	55.2	89.6	75.4		
" Mg										
" Na	118	109	129	129	17.0	129	121	116		
" K										
" Mn	1.54	0.05	0.13	0.45	0.27	0.86	15.73	16.66		
" Al	0.20	0.20	0.11	0.22	1.41	0.29	0.11	0.09		
" Cu	0.01	0.00	0.01	0.00	0.01	0.01	0.02	0.01		
" Zn	0.01	0.02	0.03	0.02	0.01	0.00	0.09	0.17		
" Sr	3.01	2.53	2.50	2.01	0.21	1.10	2.35	1.75		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 11/22/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
	Sampling Sites									
Flow, cfs					DRY					
Diss. O_2	10.8	13.8	13.8	13.0		12.6		11.0		
pH (field)	7.00	7.20	7.30	7.30		7.3	7.10	7.10		
pH (lab)	7.31	7.70	7.65	7.78		7.48	7.31	6.70		
Temp. (H_2O)	9	6	8	8		6	9	7		
Temp. (air)										
Cond.	3351	2881	3167	2881		1870	2728	2707		
Ammonia-N	0.02	0.01	0.01	0.01		0.01	4.02	2.76		
Chloride	16.2	14.4	25.3	27.9		38.6	18.6	13.5		
Fluoride	0.74	0.66	0.59	0.62		0.47	0.35	0.88		
Sulfate	2675	2418	2551	2305		1177	2373	2313		
TD Solids	4271	3787	4045	3434		2072	3396	3481		
TS Solids	38	26	30	26		16	33,637	28		
Alkalinity	329	255	326	308		233	1033	23		
Acidity	48	49	40	33		26	49	11		
Total Fe	0.53	0.03	0.03	0.10		0.21	0.09	1.77		
Diss. Fe										
" Ca	80.1	77.0	81.0	78.6		76.1	81.7	81.7		
" Mg										
" Na	116	112	129	133		173	216	137		
" K										
" Mn	2.00	0.02	0.10	0.57		2.90	15.87	18.96		
" Al	0.48	0.19	3.39	0.10		0.43	1.62	0.67		
" Cu	0.02	0.01	0.02	0.01		0.00	0.02	0.02		
" Zn	0.02	0.02	0.02	0.01		0.01	0.14	0.22		
" Sr	3.11	2.87	2.75	2.48		1.46	3.80	2.08		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Date 12/6/76

Mine Name (and/or code) ______________________

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	8.7	11.0	10.0	9.9	8.6	9.2		9.7		
pH (field)	7.20	7.10	7.10	7.10	7.50	7.20	7.00	7.30		
pH (lab)	7.38	7.97	7.66	7.74	7.78	7.57	7.52	7.11		
Temp. (H_2O)	10	7	9	9	5.5	6		7		
Temp. (air)										
Cond.	3236	2954	3015	2703	503	1388	2814	2723		
Ammonia-N	0.43	0.04	0.01	0.01	0.01	0.04	8.02	3.38		
Chloride	17.3	14.2	26.5	26.2	10.0	38.8	18.8	12.4		
Fluoride	0.47	0.61	0.55	0.45	0.26	0.23	0.32	0.55		
Sulfate	2487	2409	2447	2053	177	804	2346	2249		
TD Solids	4087	3726	3952	3276	348	1393	3193	3119		
TS Solids	31	26	27	20	58	13	58,374	21		
Alkalinity	345	291	302	278	58	196	133	27		
Acidity	76	35	46	35	9	19	33	25		
Total Fe	1.18	0.36	0.15	0.18	2.75	0.23	0.07	1.45		
Diss. Fe										
" Ca	69.3	65.1	69.5	63.0	22.8	42.1	71.5	70.0		
" Mg										
" Na	97.7	95.6	117	117	29.1	120	195	111		
" K										
" Mn	2.03	0.17	0.17	0.67	0.75	1.62	13.86	15.85		
" Al	0.06	0.06	0.04	0.06	1.87	0.04	0.04	0.06		
" Cu	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01		
" Zn	0.02	0.01	0.03	0.03	0.01	0.01	0.04	0.20		
" Sr	2.97	2.83	2.74	2.32	0.32	1.07	3.20	2.10		
" Cd	0.012	0.008	0.012	0.014	0.007	0.008	0.014	0.026		
" Co	0.01	0.01	0.01	0.00	0.00	0.01	0.12	0.07		
" Cr	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01		
" V										
" Mo										
" Ni	0.02	0.01	0.01	0.01	0.01	0.02	0.25	0.14		
" Pb	0.02	0.04	0.07	0.05	0.08	0.01	0.08	0.01		
" Hg	0.0005	0.0006	0.0007	0.0005	0.0007	0.0013	0.0011	0.0023		

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ____________________ Date 12/20/76

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	H 101	H 102	H 103	H 104	H 105	H 106	H 107	H 108		
Flow, cfs										
Diss. O_2	10.7	12.2	11.6	10.7	11.2	10.6		10.4		
pH (field)	7.10	7.20	7.10	7.10	7.40	7.30	7.00	6.90		
pH (lab)	7.22	7.90	7.72	7.73	7.63	7.59	7.31	6.60		
Temp. (H_2O)	7	4	5	5	4	4	5	5		
Temp. (air)										
Cond.	3440	3192	2881	2680	805	1453	2764	2696		
Ammonia-N	0.05	0.02	0.01	0.01	0.01	0.01	3.50	2.38		
Chloride	16.3	15.7	25.4	26.5	10.5	39.97	17.9	11.61		
Fluoride	0.41	0.54	0.48	0.38	0.22	0.19	0.26	0.47		
Sulfate	1065	2464	1388	1630	391	628	2262	2144		
TD Solids	4083	3858	2862	3270	687	1191	3733	3273		
TS Solids	23	7	14	11	3	25	22,065	17		
Alkalinity	322	366	263	261	86	172	13	112		
Acidity	52	24	30	33	19	23	18	20		
Total Fe	0.73	0.09	0.15	0.12	0.34	0.30	1.35	1.23		
Diss. Fe										
" Ca	49.6	46.1	44.2	42.7	23.1	29.1	45.6	44.5		
" Mg										
" Na	106	101	104	106	52.6	115	119	111		
" K										
" Mn	1.92	0.12	0.74	0.79	0.09	1.98	17.32	18.80		
" Al	0.05	0.07	0.03	0.05	1.66	0.03	0.05	0.05		
" Cu	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02		
" Zn	0.00	0.01	0.02	0.00	0.01	0.01	0.04	0.22		
" Sr	3.16	2.95	2.71	2.65	0.60	1.25	2.95	2.22		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine Name (and/or code) ______________________ Date 1/10/77

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	101	102	103	104	105	106	107	108		
Flow, cfs	ALL SAMPLING SITES WERE FROZEN - -					NO FLOW				
Diss. O_2										
pH (field)										
pH (lab)										
Temp. (H_2O)										
Temp. (air)										
Cond.										
Ammonia-N										
Chloride										
Fluoride										
Sulfate										
TD Solids										
TS Solids										
Alkalinity										
Acidity										
Total Fe										
Diss. Fe										
" Ca										
" Mg										
" Na										
" K										
" Mn										
" Al										
" Cu										
" Zn										
" Sr										
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ______________ Date 2/14/77

Values in mg/l (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	101	102	103	104	105	106	107	108		
Flow, cfs	1.62	1.81	2.61	16.03	2.73	8.61				
Diss. O_2	10.0	12.0	12.4	11.6	11.3	12.5		9.8		
pH (field)	7.7	8.0	7.9	8.0	7.9	7.7		8.0		
pH (lab)	7.15	7.64	7.58	7.62	7.52	7.62		7.29		
Temp. (H_2O)	8	4	4	3	2	3		3		
Temp. (air)										
Cond.	2020	1305	1657	1240	422.6	1138		1079		
Ammonia-N	0.03	0.02	0.01	0.00	0.01	0.01		0.66		
Chloride	14.38	13.09	12.28	17.19	13.12	16.79		11.21		
Fluoride	0.32	0.25	0.29	0.20	0.09	0.02		0.34		
Sulfate	2016	1543	1647	1151	247	873		1564		
TD Solids		1583		1896	500	1711				
TS Solids	41	25	31	26	28	33		19		
Alkalinity	357	201	224	207	65q	220		22		
Acidity	137	41	51	31	19	36		36		
Total Fe	0.46	0.02	0.05	0.39	0.92	0.40		0.91		
Diss. Fe										
" Ca	45.2	35.0	39.2	26.9	10.8	24.0		36.1		
" Mg										
" Na	44.5	49.7	49.6	121.0	43.0	124.0		57.7		
" K										
" Mn	2.90	1.12	0.99	0.91	0.21	0.96		11.71		
" Al	1.08	0.40	0.25	0.93	1.42	0.99		0.99		
" Cu	0.00	0.00	0.02	0.00	0.00	0.03		0.01		
" Zn	0.01	0.20	0.01	0.00	0.01	0.01		0.19		
" Sr	2.66	1.76	2.14	1.51	0.26	1.63		1.69		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) __________ Date 2/28/77

Values in mg/l (except cond., pH, flow, and temp.)

Parameter	101	102	103	104	105	106	107	108		
Flow, cfs	1.74	2.10	5.34	17.45	1.16	6.56	DRY			
Diss. O_2	10.6	13.6	11.2	11.4	10.8	12.2		9.4		
pH (field)										
pH (lab)	7.62	7.97	7.81	7.90	7.80	7.92		7.29		
Temp. (H_2O)	14	11	9.5	11	10	10		10		
Temp. (air)										
Cond.	4145	3400	3592	3479	700	1987		3467		
Ammonia-N	0.05	0.04	0.03	0.03	0.09	0.10		1.63		
Chloride	17.02	16.52	18.36	17.37	15.41	19.20		16.39		
Fluoride	0.64	0.62	0.55	0.42	0.15	0.29		0.64		
Sulfate	2599	2227	2205	1443	362			2200		
TD Solids	4140	3468	3552	2388	544	1947		3233		
TS Solids	28	19	2	12	4	1		6		
Alkalinity	222	282	222	293	93.1	236		46		
Acidity	98	57	55	41	12	31		53		
Total Fe	0.63	0.15	0.26	0.11	0.87	0.18		1.10		
Diss. Fe										
" Ca	112	99.7	103	86.5	35.3	88.7		110		
" Mg										
" Na	100	97.3	108	202	54.5	202		105		
" K										
" Mn	2.80	0.62	0.79	0.77	0.18	0.82		18.61		
" Al	0.46	0.17	0.32	0.24	0.89	0.48		0.00		
" Cu	0.01	0.01	0.03	0.01	0.00	0.00		0.02		
" Zn	0.02	0.01	0.03	0.01	0.01	0.00		0.29		
" Sr	2.35	1.94	1.98	1.52	0.28	1.48		1.74		
" Cd	0.025	0.019	0.025	0.027	0.022	0.023		0.042		
" Co	0.18	0.21	0.19	0.14	0.11	0.02		0.26		
" Cr	0.04	0.02	0.05	0.03	0.01	0.03		0.03		
" V										
" Mo										
" Ni	0.16	0.09	0.08	0.06	0.07	0.13		0.57		
" Pb	0.02	0.04	0.04	0.05	0.06	0.03		0.02		
" Hg	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000		

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ______________ Date 3/16/77

Values in mg/l (except cond., pH, flow, and temp.)

	Sampling Sites							
Parameter	101	102	103	104	105	106	107	108
Flow, cfs	1.03	2.40	1.70	19.45	1.35	11.26		
Diss. O_2	10.0	11.0	9.6	10.8	9.8	10.6		9.3
pH (field)	8.10	7.70	8.10	7.90	8.00	7.80		8.00
pH (lab)	7.30	7.81	7.78	7.79	7.61	7.71q	7.30	7.38
Temp. (H_2O)	15	14	16	15	13	15	15	14
Temp. (air)								
Cond.	2671	1895	2219	1565	712	1393	2060	2213
Ammonia-N	0.05	0.03	0.02	0.02	0.06	0.06	2.42	2.42
Chloride	17.69	16.35	20.59	16.26	16.84	18.76	14.11	17.42
Fluoride	0.67	0.64	0.53	0.42	0.15	0.28	0.06	0.66
Sulfate	2464	897	1940	1009	384q	758	2094	1952
TD Solids	3897	2439	2941	1610	486	1202	3371	2530
TS Solids	49	35	40	32	14	28	20,839	31
Alkalinity	377	220	243	222	103	163	86	41
Acidity	146	55	38	33	22	24	21	24
Total Fe	0.56	0.03	0.04	0.34	0.06	0.07	0.03	0.42
Diss. Fe								
" Ca	112	100	103	87.0	35.9	88.9	81.7	112
" Mg								
" Na	70.4	67.5	75.0	203	47.9	206	62	72.9
" K								
" Mn	2.25	0.57	0.58	0.80	0.12	0.87	14.11	15.77
" Al	0.51	0.16	0.37	0.24	0.95	0.58	0.61	0.03
" Cu	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01
" Zn	0.02	0.01	0.03	0.01	0.02	0.01	0.03	0.30
" Sr	2.37	2.02	1.77	1.41	0.28	1.44	1.55	1.59
" Cd								
" Co								
" Cr								
" V								
" Mo								
" Ni								
" Pb								
" Hg								

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ______________ Date 3/31/77

Values in mg/l (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	101	102	103	104	105	106	107	108		
Flow, cfs	3.65	10.27	17.73		5.81					
Diss. O_2	10.8	10.6	9.8	9.6	9.8	9.8		9.2		
pH (field)	7.0	7.3	7.3	7.2	7.4	7.2	7.8	8.0		
pH (lab)	7.51	7.88	7.72	7.65	7.70	7.50	6.74	6.05		
Temp. (H_2O)	19	18	17	18	18	17	18	18		
Temp. (air)										
Cond.	3107	1844	1894	1300	682	1212	3132	2092		
Ammonia-N	0.06	0.05	0.03	0.03	0.08	0.10	2.12	2.39		
Chloride	17.42	16.79	20.54	16.52	16.93	18.27	14.69	17.06		
Fluoride	0.64	0.56	0.48	0.39	0.14	0.26	0.06	0.55		
Sulfate	1964	958	661	537	299	477	2299	1407		
TD Solids	3354	1613	1795	1095	441	916	3514	2043		
TS Solids	28	15	12	22	18	18	24	10		
Alkalinity	380	197	156	112	93	123	65	19		
Acidity	106	16	23	25	21	20	114	143		
Total Fe	1.27	0.31	0.13	0.96	1.02	1.38	3.25	27.78		
Diss. Fe										
" Ca	123	108	112	94.4	35.5	87.6	80.2	123		
" Mg										
" Na	13.2	13.2	14.7	18.6	9.96	19	12.3	14.4		
" K										
" Mn	1.35	0.48	0.44	0.66	0.08	0.71	10.45	8.17		
" Al	0.44	0.17	0.34	0.17	0.77	0.47	0.57	0.06		
" Cu	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.03		
" Zn	0.02	0.01	0.01	0.00	0.01	0.01	0.08	0.45		
" Sr	2.44	2.01	1.81	1.46	0.26	1.44	1.57	1.63		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ____________ Date 4/12/77

Values in mg/l (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	101	102	103	104	105	106	107	108		
Flow, cfs	3.70	5.42	5.57	16.89	1.36	8.98				
Diss. O_2	10.2	10.6	9.2	10.2	9.8	10.4		8.6		
pH (field)	7.9	6.7	7.1	7.2	7.1	7.3	5.9	4.8		
pH (lab)	7.60	7.91	7.92	7.88	7.87	7.93	7.52	4.40		
Temp. (H_2O)	25	23	23	22	22	23	23	22		
Temp. (air)										
Cond.	2947	1616	1543	1252	677	1092	2731	1821		
Ammonia-N	1.15	0.21	0.07	0.06	0.05	0.04	2.42	2.09		
Chloride	14.34	14.29	16.12	16.93	18.40	16.61	17.73	17.77		
Fluoride	0.49	0.39	0.44	0.32	0.14	0.19	0.49	0.54		
Sulfate	1801	1009	742	1182	269	574	2049	1401		
TD Solids	3324	1717	1790	1001	497	990		2090		
TS Solids	32.8	32.8	18.8	34.4	12.0	32.0	29,490	32.8		
Alkalinity	350	268	254	198	92	159	55	0		
Acidity	104	43	24	43	22	18	36	55		
Total Fe	0.69	0.26	0.33	0.23	0.22	0.29	1.55	2.16		
Diss. Fe										
" Ca	95.8	84.5	83.6	72.7	35.1	86.6	82.0	98.2		
" Mg										
" Na	56.3	53.2	54.5	92.2	25.4	98.3	130	51.4		
" K										
" Mn	1.32	0.70	0.57	0.57	0.14	0.68	8.59	13.67		
" Al	0.46	0.17	0.36	0.30	0.96	0.63	0.63	0.07		
" Cu	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.07		
" Zn	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.56		
" Sr	2.82	2.11	1.94	1.45	0.40	1.15	2.75	1.26		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ______________________ Date 4/27/77

Values in mg/l (except cond., pH, flow, and temp.)

Parameter	Sampling Sites 101	102	103	104	105	106	107	108		
Flow, cfs	3.42	13.10	8.21	25.12	1.49	8.24				
Diss. O_2	10.0	8.6	8.4	8.6	9.8	8.4		8.4		
pH (field)	7.6	6.3	7.2	7.3	7.1	6.8	7.6	4.8		
pH (lab)	7.48	7.79	7.85	7.80	7.66	7.63	7.40	4.16		
Temp. (H_2O)	22	21	23	23	19	24	22	20		
Temp. (air)										
Cond.	3177	2966	2700	2166	669	1533	2655	2479		
Ammonia-N	0.04	0.01	0.01	0.01	0.01	0.01	3.67	2.40		
Chloride	14.69	12.95	17.10	17.06	17.37	17.02	18.85	17.77		
Fluoride	0.34	0.28	0.29	0.26	0.10	0.12	0.49	0.50		
Sulfate	2309	1964	2011	1123	333	621	1537	586		
TD Solids	3671	3148	2971		458	1127	2908	2464		
TS Solids	28.8	22.8	23.6	15.2	173.6	3.20	2336	16.4		
Alkalinity	370	289	190	188	92	122	47	0		
Acidity	82	45	32	22	23	19	20	56		
Total Fe	0.43	0.11	0.12	0.19	0.14	0.15	0.13	0.42		
Diss. Fe										
" Ca	501	384	424	291	52.4	85	328	409		
" Mg										
" Na	61.6	56.4	57.9	61.1	42.6	96	290	61.0		
" K										
" Mn	1.49	0.12	0.11	0.10	0.05	0.17	9.38	15.13		
" Al	2.21	3.80	3.27	3.45	2.35	1.68	1.55	4.31		
" Cu	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.02		
" Zn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04		
" Sr	2.82	2.12	2.27	0.78	0.34	1.12	3.13	1.64		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" "										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ______________________ Date 5/9/77

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	101	102	103	104	105	106	107	108		
Flow, cfs										
Diss. O_2	9.2	9.3	8.8	8.3	11.2	8.1		8.1		
pH (field)	6.3	7.8	7.2	7.3	7.7	7.2	6.9	4.5		
pH (lab)	7.22	7.60	7.72	7.76	8.01	7.70	7.41	4.09		
Temp. (H_2O)	22	23	23	24	20	24	24	22		
Temp. (air)										
Cond.	3870	3517	3228	2202	791	1657	2961	1828		
Ammonia-N	0.12	0.04	0.02	0.04	0.04	0.04	3.39	2.10		
Chloride	17.51	12.50	15.18	14.69	17.77	17.01	17.91	18.49		
Fluoride	0.26	0.25	0.27	0.23	0.10	0.10	0.49	0.47		
Sulfate	2378	2089	1950	1213	319	759	2130	1932		
TD Solids		3617	3246	2233	599					
TS Solids	5.6	6.8	13.2	1.2	14.8	16	1860	13.6		
Alkalinity	383	300	277	203	101	157	49	0		
Acidity	108	84	72	44	10	36	40	67		
Total Fe	0.48	0.05	0.06	0.21	0.07	0.20	0.10	0.30		
Diss. Fe										
" Ca	80.7	84	73.6	65.7	27.2	43.9	74.8	79.2		
" Mg										
" Na	91.5	82.5	86.0	90.3	43.2	41.7	281	92.1		
" K										
" Mn	1.22	0.07	0.10	0.07	0.03	0.09	10.98	16.04		
" Al	2.01	3.80	3.25	3.23	1.82	1.50	1.65	4.37		
" Cu	0.03	0.02	0.00	0.01	0.00	0.01	0.01	0.05		
" Zn	0.01	0.01	0.00	0.00	0.02	0.01	0.02	0.43		
" Sr	2.94	2.10	2.24	0.80	0.41	1.26	3.01	1.73		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ______________ Date 5/23/77

Values in mg/ℓ (except cond., pH, flow, and temp.)

Parameter	101	102	103	104	105	106	107	108		
Flow, cfs										
Diss. O_2	8.6	8.6	7.4	7.0		8.2		7.6		
pH (field)	7.5	6.4	6.8	6.9		7.0	7.0	4.9		
pH (lab)	7.42	7.72	7.81	7.79		7.88	7.58	5.79		
Temp. (H_2O)	26	28	29	28		29	26	27		
Temp. (air)										
Cond.	3496	3705	3307	2738		1762		3108		
Ammonia-N	0.08	0.01	0.01	0.03		0.07	4.40	3.60		
Chloride	12.86	16.12	15.14	19.56		33.36	21.35	16.61		
Fluoride	0.48	0.25	0.33	0.37		0.28	0.52	0.79		
Sulfate	2209	2144	1985	1517		875	2275	1955		
TD Solids	4167	3830	3320	2853		1450	4014	3039		
TS Solids	38	40	42	195		39	1402	37		
Alkalinity	458	326	291	224		235	68	18		
Acidity	78	40	28	17		10	31	43		
Total Fe	1.05	0.36	0.10	0.12		0.21	0.08	0.27		
Diss. Fe										
" Ca	402	377	367	140		93.8	457	397		
" Mg										
" Na	58.1	74.5	65.3	112		112	229	842		
" K	8.09	7.78	6.86	6.90		7.89	21.11	11.36		
" Mn	1.08	0.32	0.29	0.31		0.61	9.20	11.14		
" Al	0.83	1.19	0.62	1.39		0.48	0.47	0.09		
" Cu	0.02	0.01	0.02	0.01		0.01	0.02	0.03		
" Zn	0.02	0.02	0.01	0.01		0.00	0.01	0.38		
" Sr	2.31	1.93	1.77	1.60		0.97	3.66	1.68		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										

ARGONNE NATIONAL LABORATORY - LCT Water Data

Mine-Name (and/or code) ____________________ Date 6/6/77

Values in mg/l (except cond., pH, flow, and temp.)

	Sampling Sites							
Parameter	101	102	103	104	105	106	107	108
Flow, cfs					DRY			
Diss. O_2	7.8	8.1	7.0	6.6		6.6		7.2
pH (field)	7.3	6.7	7.4	7.5		7.2	7.1	6.0
pH (lab)	7.29	7.62	7.69	7.68		7.58	7.49	5.48
Temp. (H_2O)	29	30.5	32	33		31	28	30
Temp. (air)								
Cond.	4126	3987	3718	2933		1998		3390
Ammonia-N	0.05	0.01	0.01	0.01		0.01	4.80	2.80
Chloride	14.14	16.17	15.85	18.22		18.80	22.11	16.61
Fluoride	0.22	0.15	0.03	0.17		0.13	0.30	0.43
Sulfate	2156	2120	2011	1414		950	2088	2018
TD Solids	4275	3972	3567	2536		1543	4259	3245
TS Solids	30.8	31.2	19.2	16.4		17.6	79,262	23.6
Alkalinity	366	289	224	201		207	58	0
Acidity	78	60	47	22		31	33	43
Total Fe	0.18	0.09	0.10	0.12		0.04	0.8	0.19
Diss. Fe								
" Ca	133	125	122	94.6		73.8	145	131
" Mg								
" Na	87.4	83.9	83.1	105		120	30.3	114
" K								
" Mn	0.81	0.03	0.01	0.03		0.09	10.53	15.65
" Al	0.73	0.36	0.73	0.65		0.78	0.48	2.19
" Cu	0.01	0.04	0.00	0.01		0.03	0.03	0.02
" Zn	0.02	0.02	0.02	0.01		0.22	0.01	0.40
" Sr	2.67	2.16	2.05	1.64		1.44	3.20	1.80
" Cd	0.013	0.018	0.012	0.013		0.008	0.064	0.026
" Co	0.01	0.01	0.00	0.01		0.01	0.17	0.21
" Cr	0.00	0.00	0	0		0	0.00	0.00
" V								
" Mo								
" Ni	0.01	0.01	0.01	0.01		0.02	0.22	0.22
" Pb	0.12	0.19	0.11	0.02		0.09	0.29	0.26
" Hg								

ARGONNE NATIONAL LABORATORY - ECT Water Data

Mine-Name (and/or code) ______________________ Date 6/20/77

Values in mg/ℓ (except cond., pH, flow, and temp.)

	Sampling Sites									
Parameter	101	102	103	104	105	106	107	108		
Flow, cfs					DRY					
Diss. O_2	8.4	8.4	7.6	7.9		7.2		7.7		
pH (field)	7.6	7.8	7.6	7.5		7.4	6.0	5.0		
pH (lab)	6.91	7.61	7.69	7.71		7.59	7.39	4.09		
Temp. (H_2O)	25	28	28	28.5		27	27	28		
Temp. (air)										
Cond.	4007	3878	3291	3579		2287	3878	3599		
Ammonia-N	0.06	0.01	0.01	0.02		0.03	2.25	2.60		
Chloride	16.03	14.92	16.57	16.12		18.76	26.17	24.70		
Fluoride	0.43	0.24	0.32	0.33		0.29	0.82	0.88		
Sulfate	2237	1945	2220	2395		1107	1946	2319		
TD Solids	4916	4676	4438	4252		2131	4455	2575		
TS Solids	52.8	48.8	43.6	40.4		22.8	1856.0	33.6		
Alkalinity	440	278	217	232		236	29	0		
Acidity	1396	373	763	808		568	338	1017		
Total Fe	0.25	0	0	0.07		0.08	0.02	0.21		
Diss. Fe										
" Ca	199	200	202	196		153	381	543		
" Mg										
" Na	998	982	950	974		1448	1403	1243		
" K										
" Mn	0.67	0.01	0	0		0.35	21.62	24.17		
" Al	0.16	0.45	0	0.23		0.44	0.45	2.09		
" Cu	0.01	0.03	0.00	0.02		0.00	0.00	0.01		
" Zn	0.01	0.01	0.01	0.01		0.00	0.04	0.37		
" Sr	3.27	2.82	2.66	2.67		1.69	2.74	2.59		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

ARGONNE NATIONAL LABORATORY - ECT Water Data

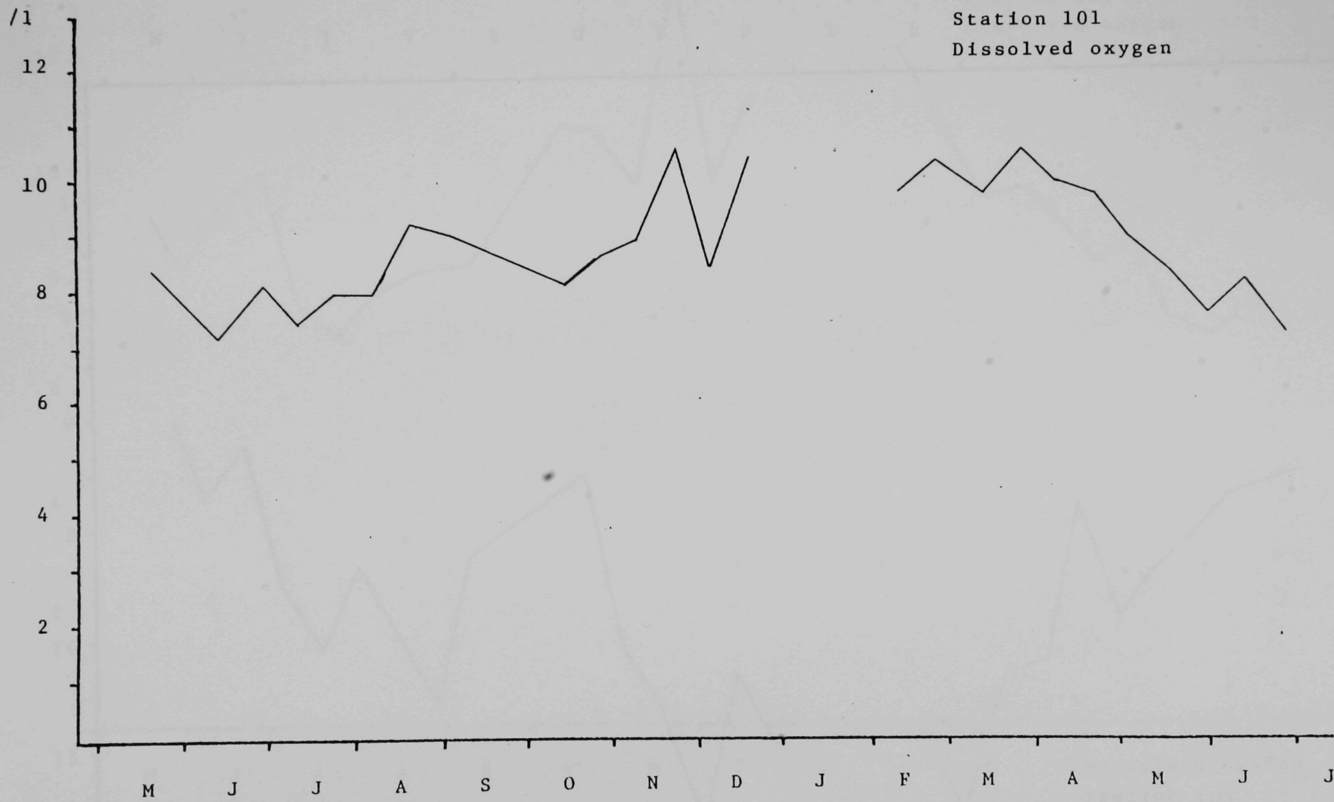
Mine-Name (and/or code) ______________ Date 7/5/77

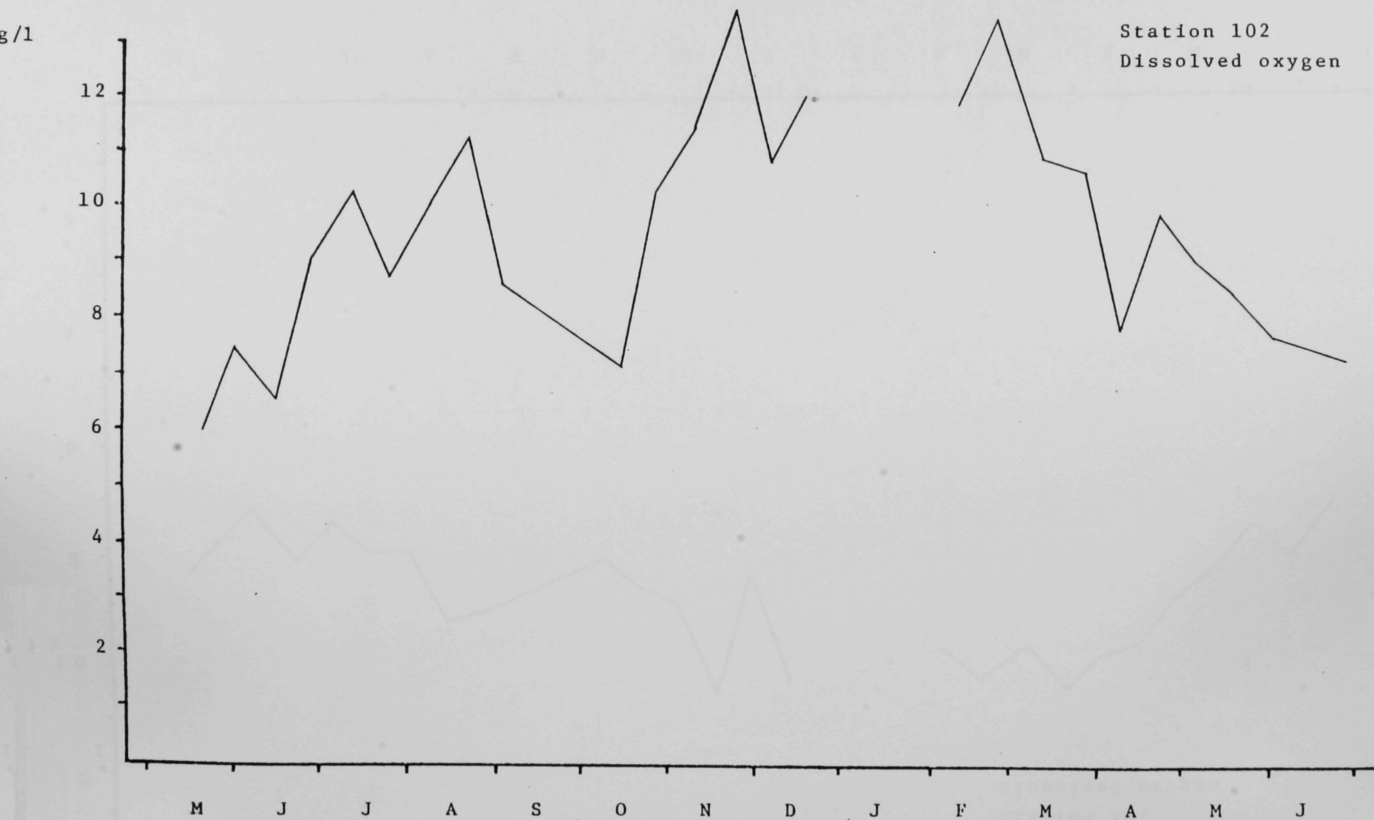
Values in mg/l (except cond., pH, flow, and temp.)

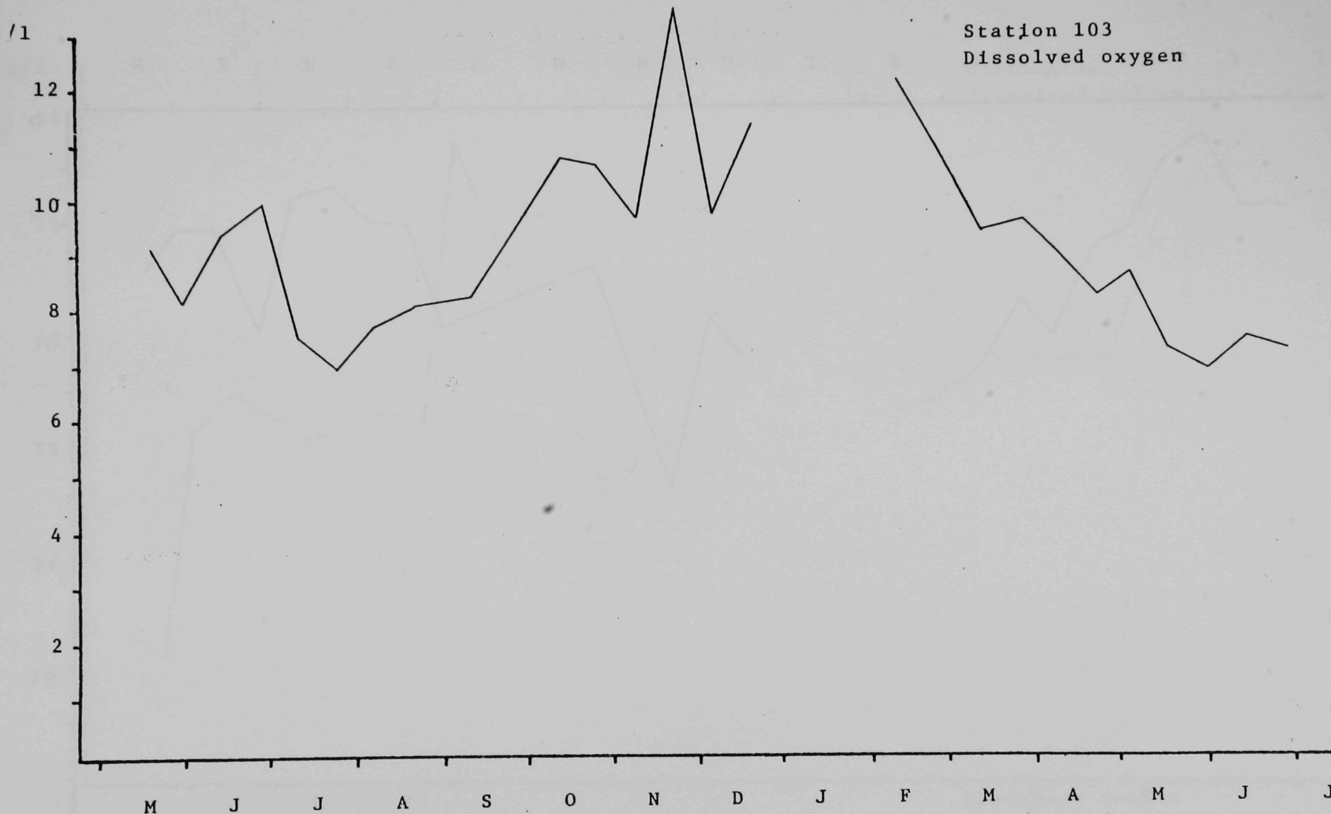
	Sampling Sites									
	101	102	103	104	105	106	107	108		
Parameter		-								
Flow, cfs	2.93	2.05	2.36	7.01	DRY	3.70				
Diss. O_2	9.2	9.6	7.4	7.9		7.4		7.8		
pH (field)	7.4	7.4	7.6	7.8		7.1	7.5	6.3		
pH (lab)	7.00	7.53	7.51	7.51		7.32	7.06	3.35		
Temp. (H_2O)	31	34	34	35		32	32	32		
Temp. (air)										
Cond.	4128	3235	3353	3235		1971	2853	3030		
Ammonia-N	0.03	0.01	0.01	0.01		0.01	5.22	2.12		
Chloride	16.03	15.99	16.12	19.07		17.82	29.83	23.71		
Fluoride	0.27	0.16	0.16	0.16		0.14	0.59	0.52		
Sulfate	2092	1239	1924	1956		207	1904	1664		
TD Solids	4211	3272	3713	3181		1832	3693	3310		
TS Solids	58.4	44.0	48.0	46.4		29.6	484.0	40.4		
Alkalinity	337	189	186	245		185	94	0		
Acidity	1727	739	763	703		454	508	1250		
Total Fe	0.32	0.11	0.04	0.03		0.27	0.04	0.82		
Diss. Fe										
" Ca	72.4	55.3	67.7	53.9		37.0	77.1	71.1		
" Mg										
" Na	117.0	85.9	117.0	146.0		268.0	441.0	162.0		
" K										
" Mn	0.85	0.18	0.01	0.08		0.08	11.39	23.26		
" Al	0.01	0.01	0.00	0.05		0.03	0.07	6.71		
" Cu	0.01	0.04	0.00	0.00		0.01	0.02	0.03		
" Zn	0.02	0.04	0.01	0.03		0.04	0.02	0.58		
" Sr	2.66	1.64	1.99	1.65		1.20	3.10	1.57		
" Cd										
" Co										
" Cr										
" V										
" Mo										
" Ni										
" Pb										
" Hg										

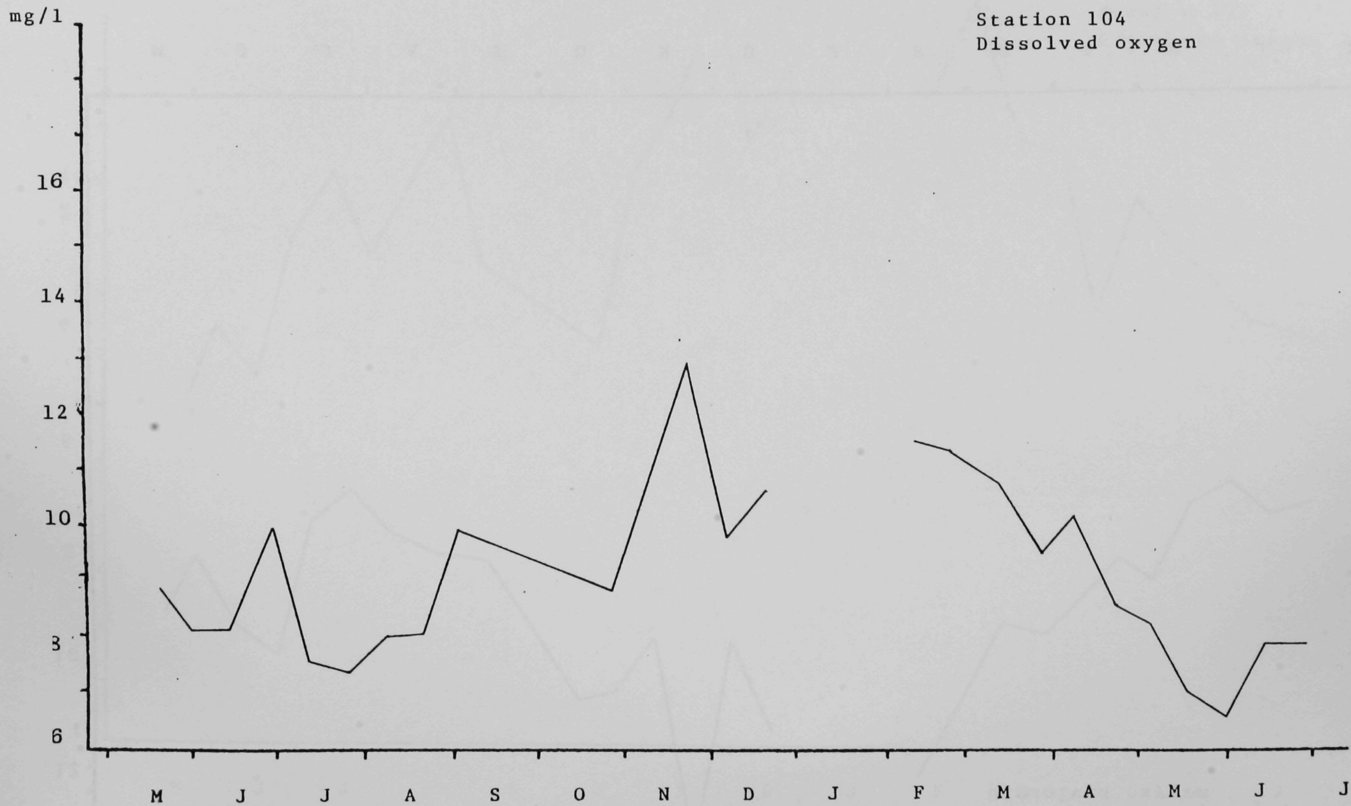
Appendix F

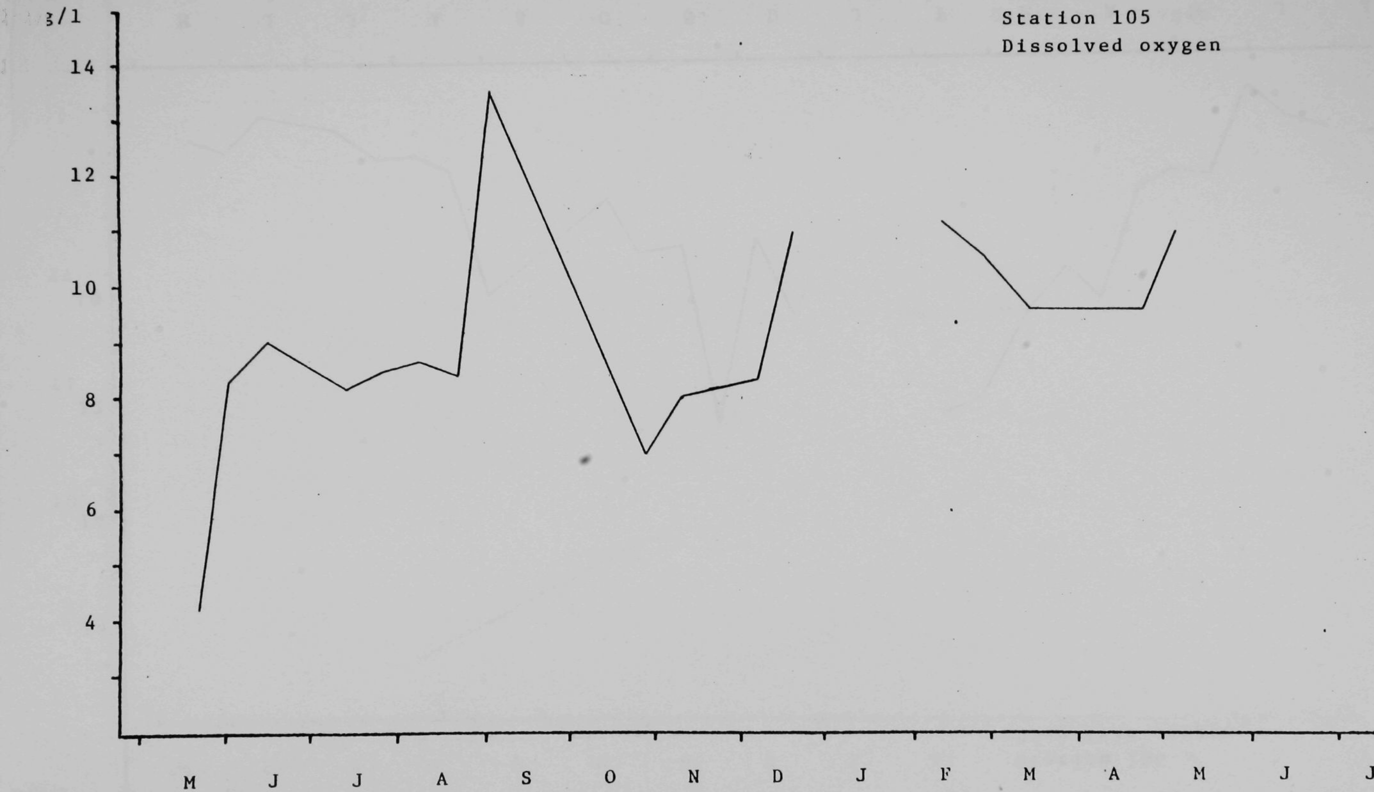
Graphs of Water Quality Parameters as a Function of Time

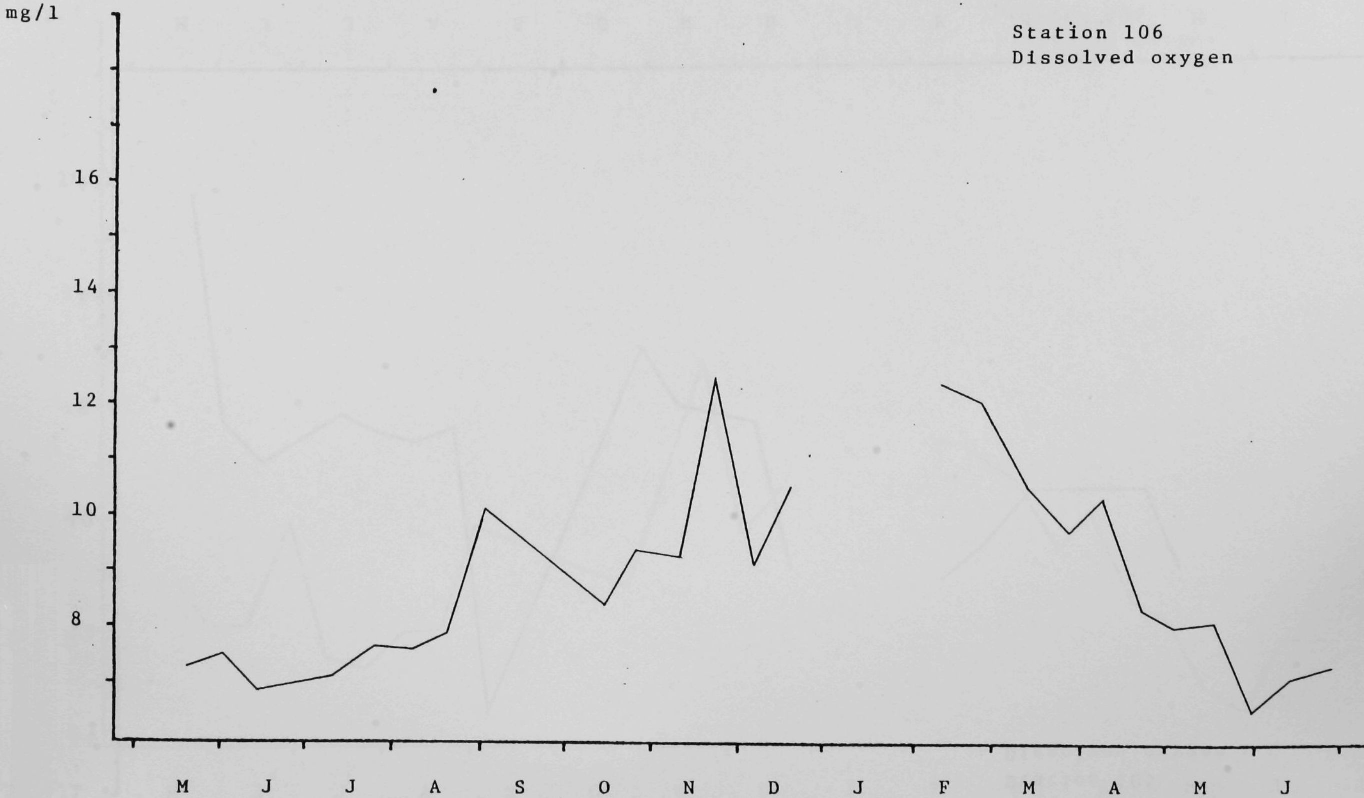

Station 101
Dissolved oxygen
/1
12
10
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

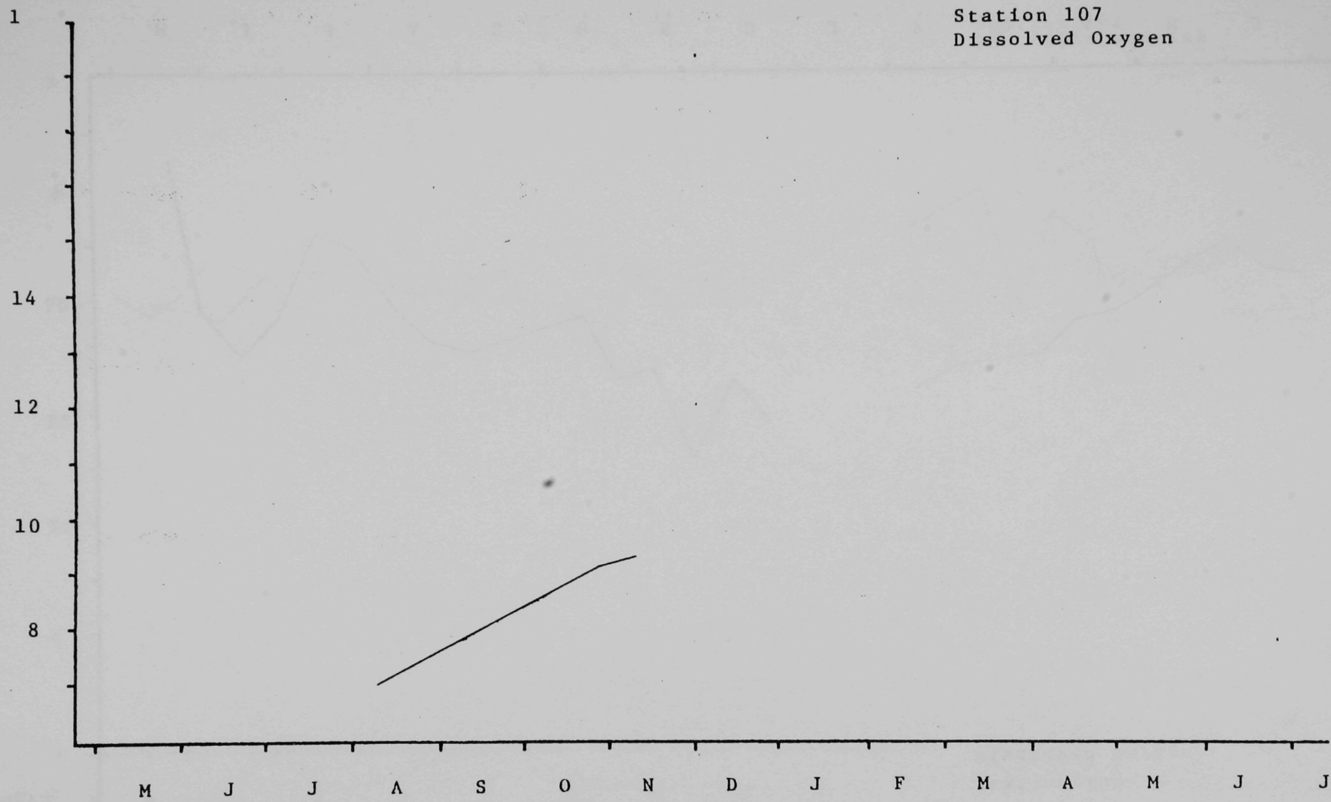

g/l
Station 102
Dissolved oxygen
12
10
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J

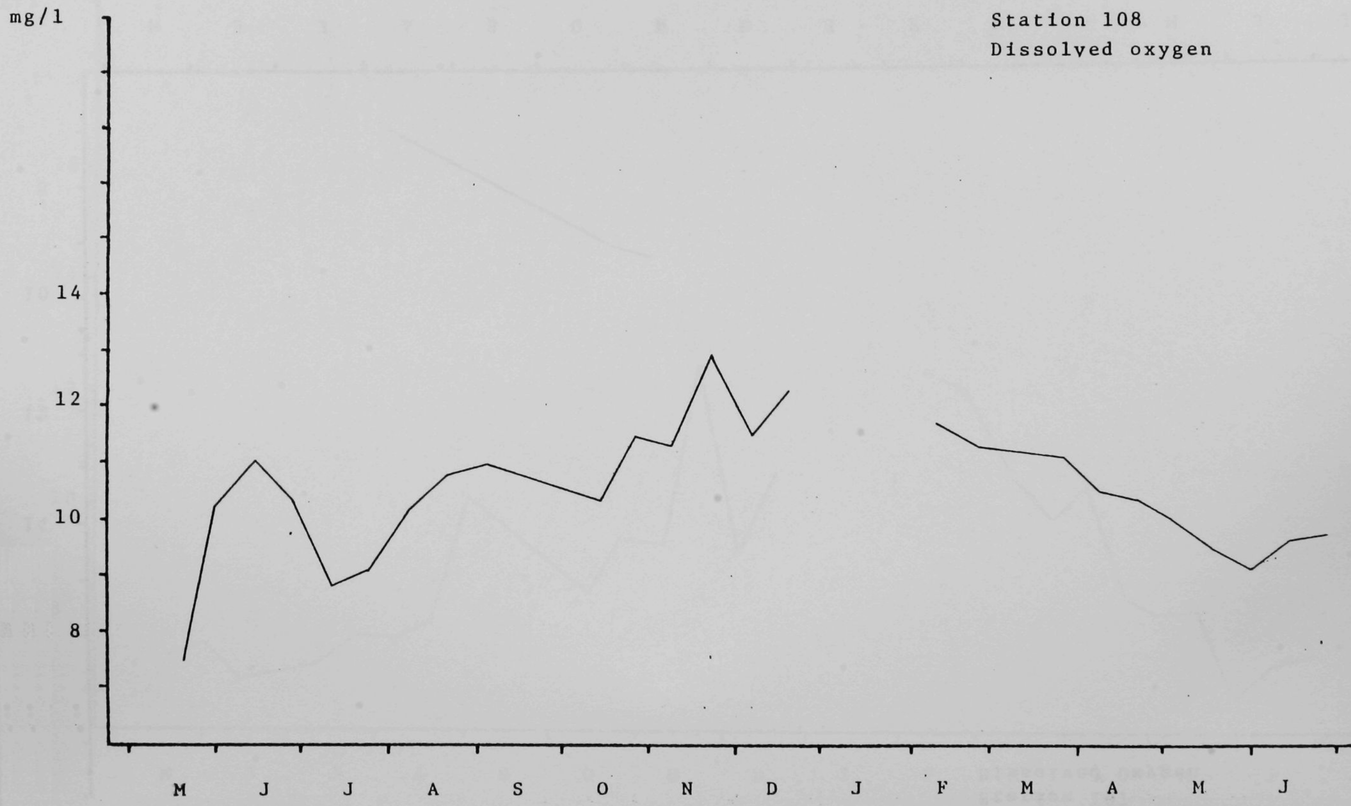

Station 103
Dissolved oxygen
/1
12
10
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

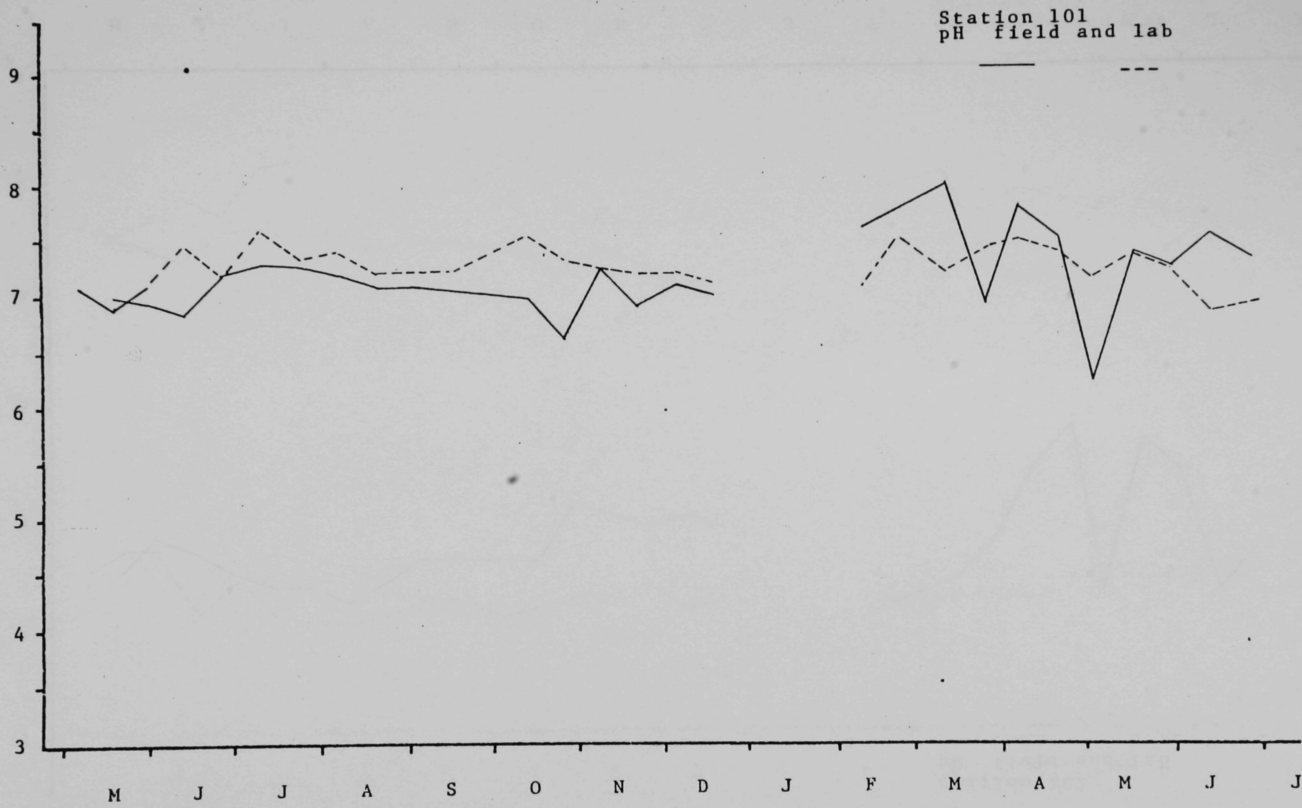

Station 104
Dissolved oxygen
mg/1
16
14
12
10
8
6
M J J A S O N D J F M A M J J

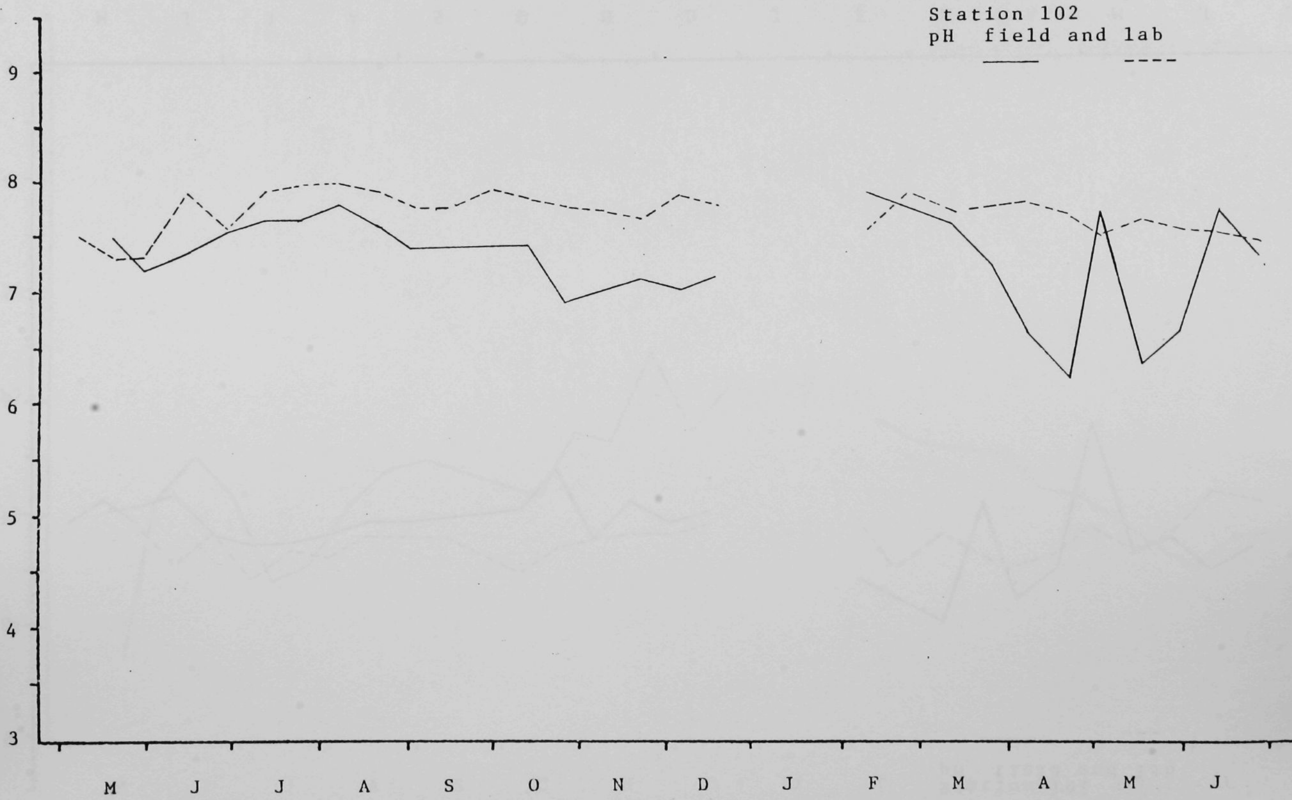

Station 105
Dissolved oxygen
g/l
14
12
10
8
6
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

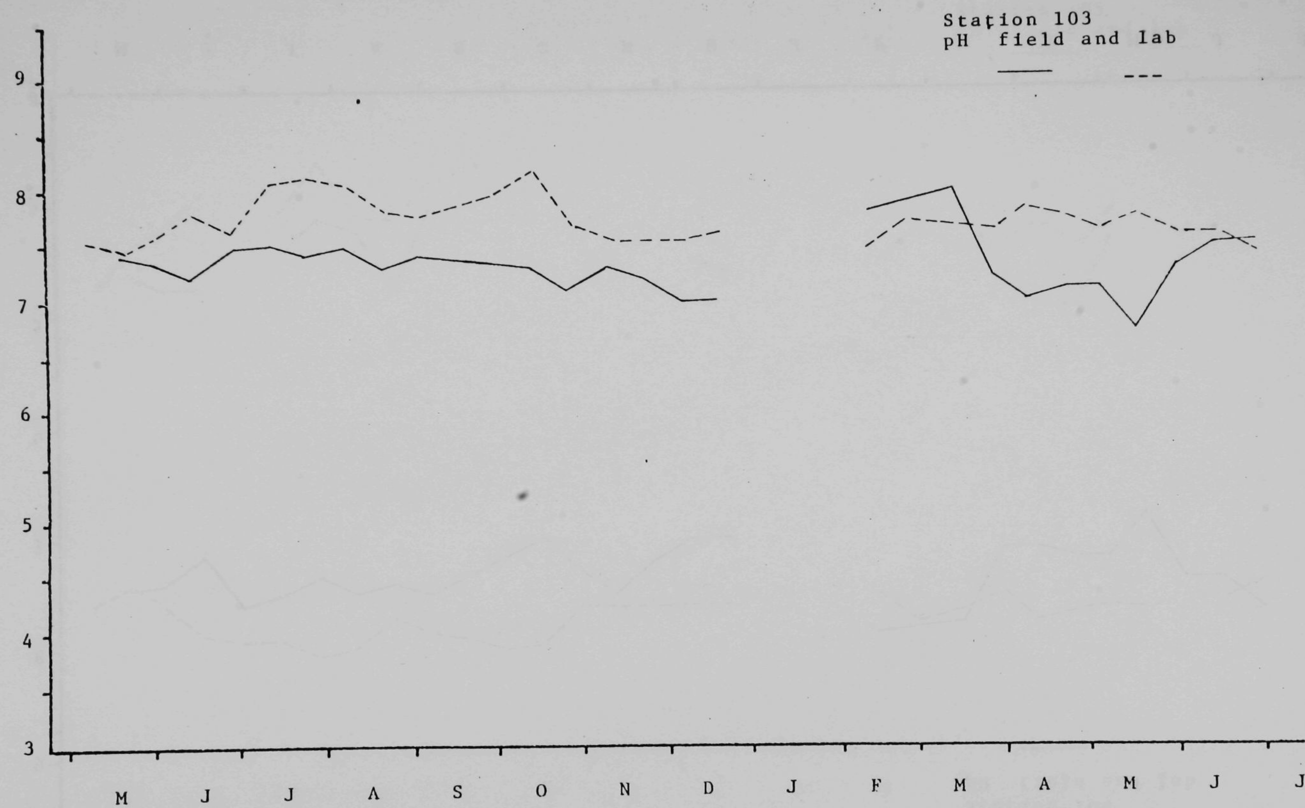

mg/l
Station 106
Dissolved oxygen
16
14
12
10
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J

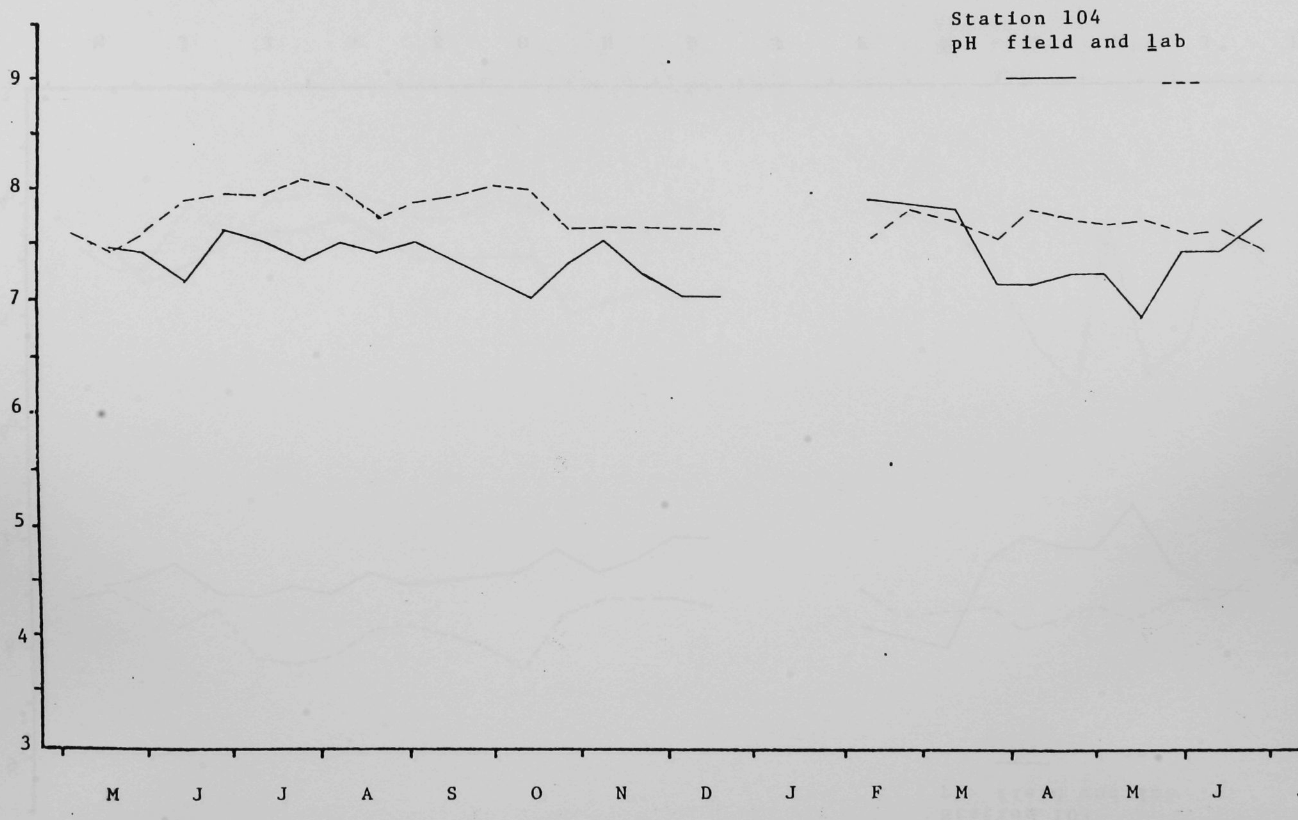

Station 107
Dissolved Oxygen
1
14
12
10
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


mg/1
Station 108
Dissolved oxygen
14
12
10
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J

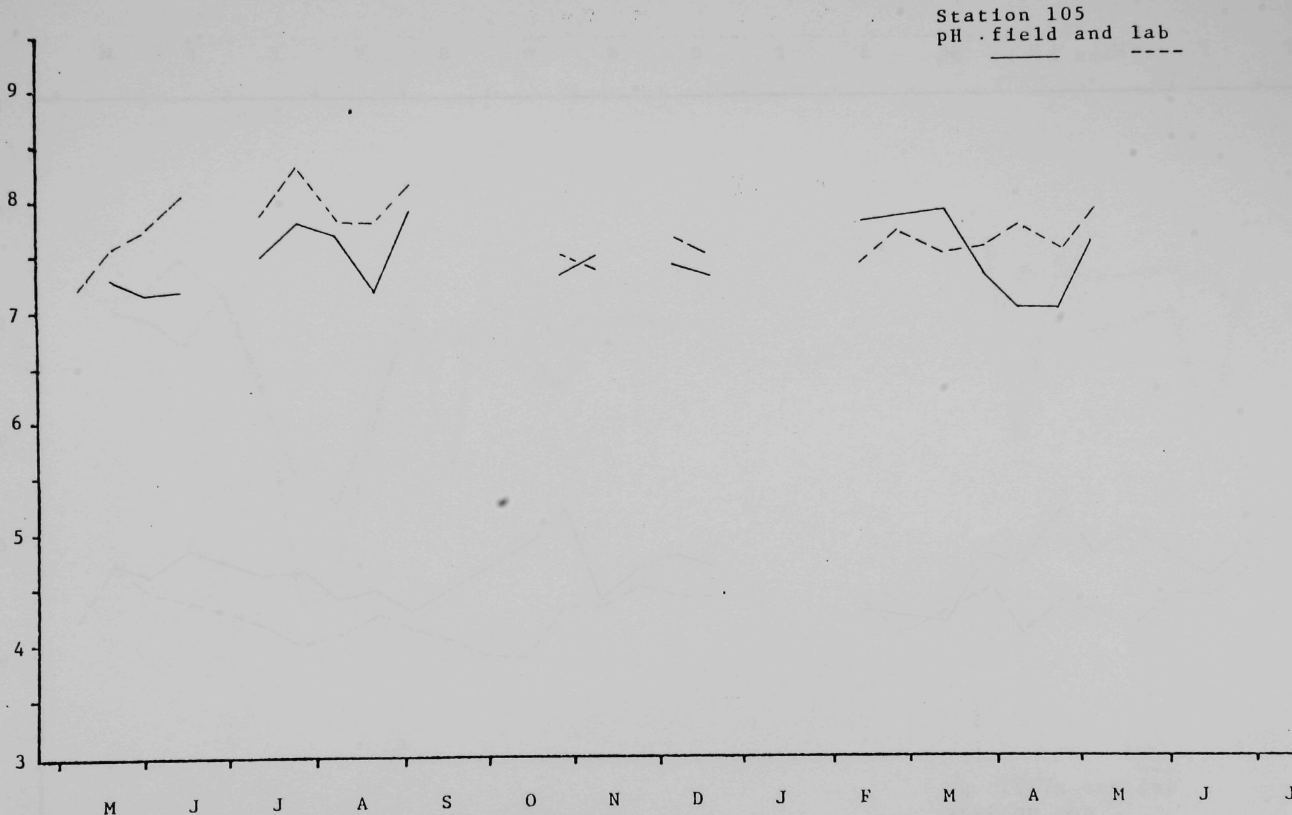

Station 101
pH field and lab
9
8
7
6
5
4
3
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

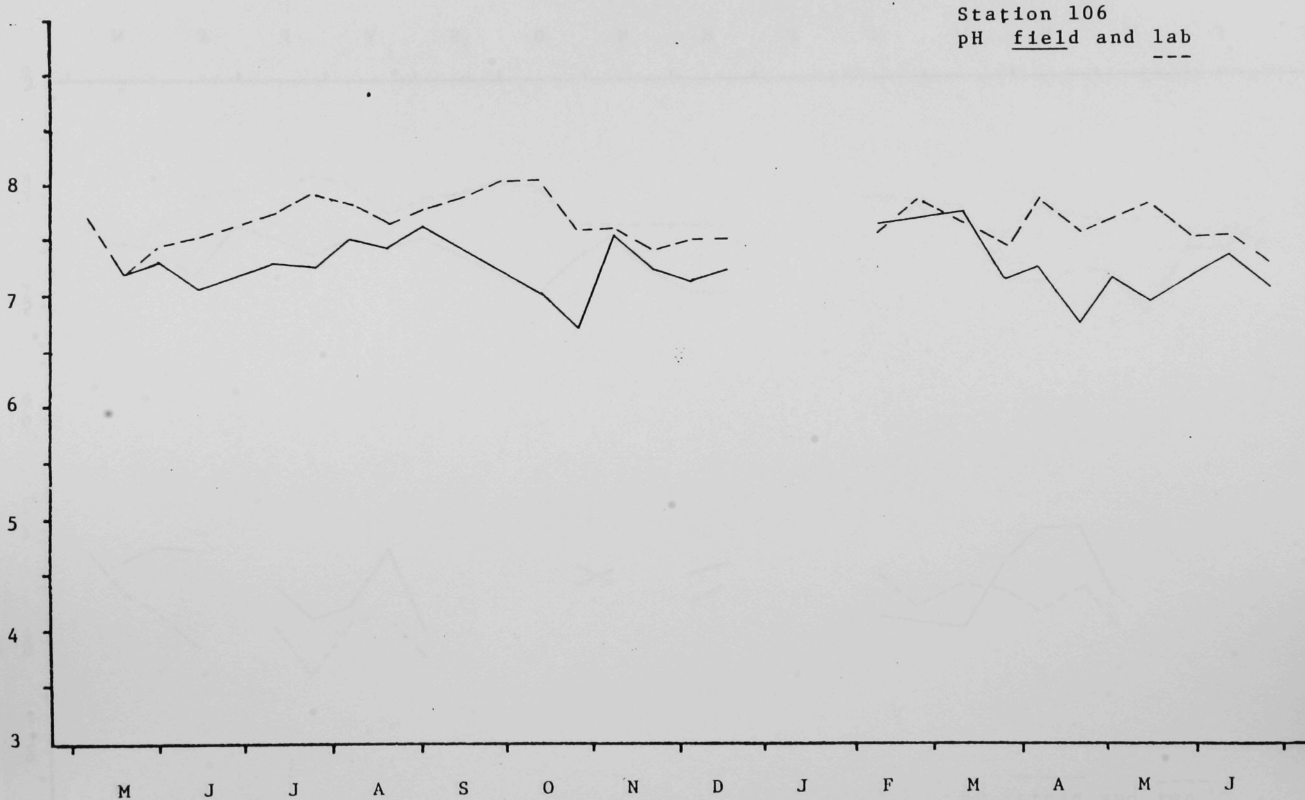

Station 102
pH field and lab
9
8
7
6
5
4
3
M
J
J
A
S
O
N
D
J
F
M
A
M
J

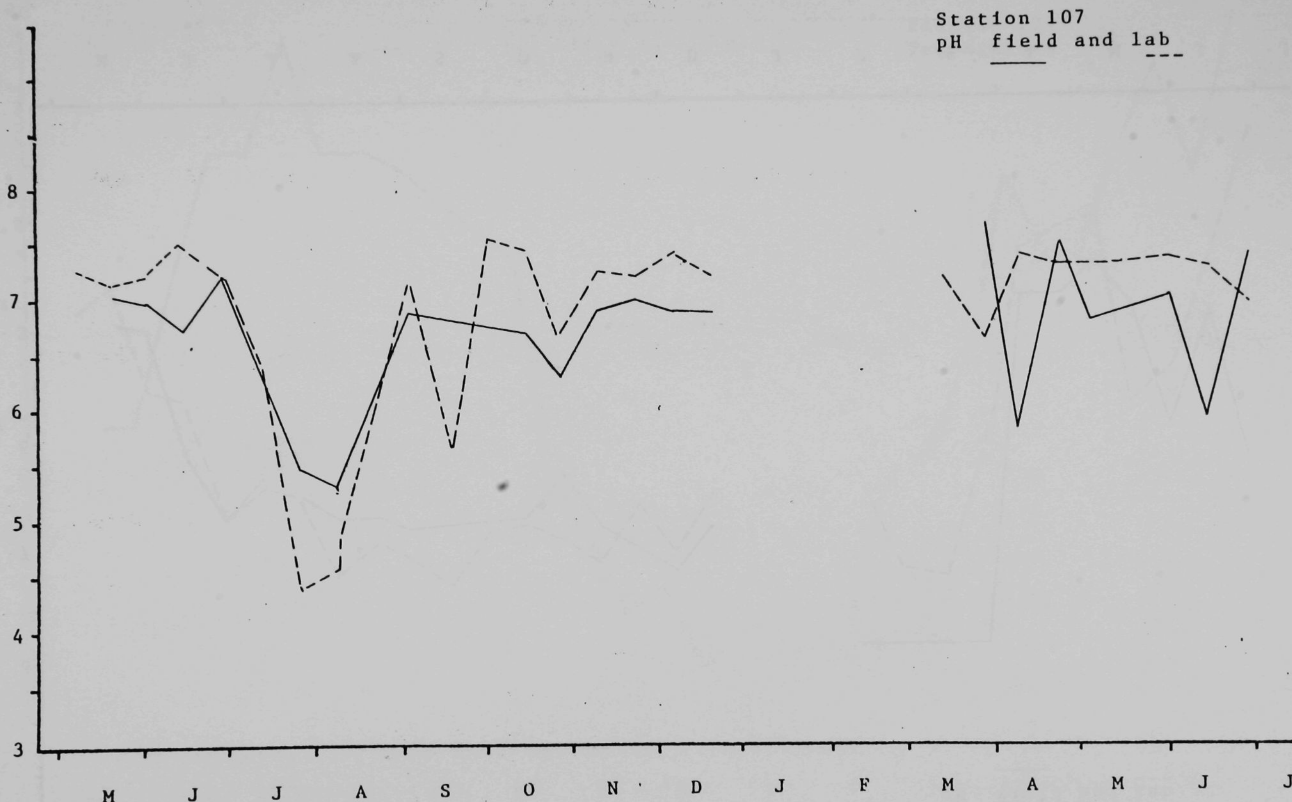

Station 103
pH field and lab
9
8
7
6
5
4
3
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

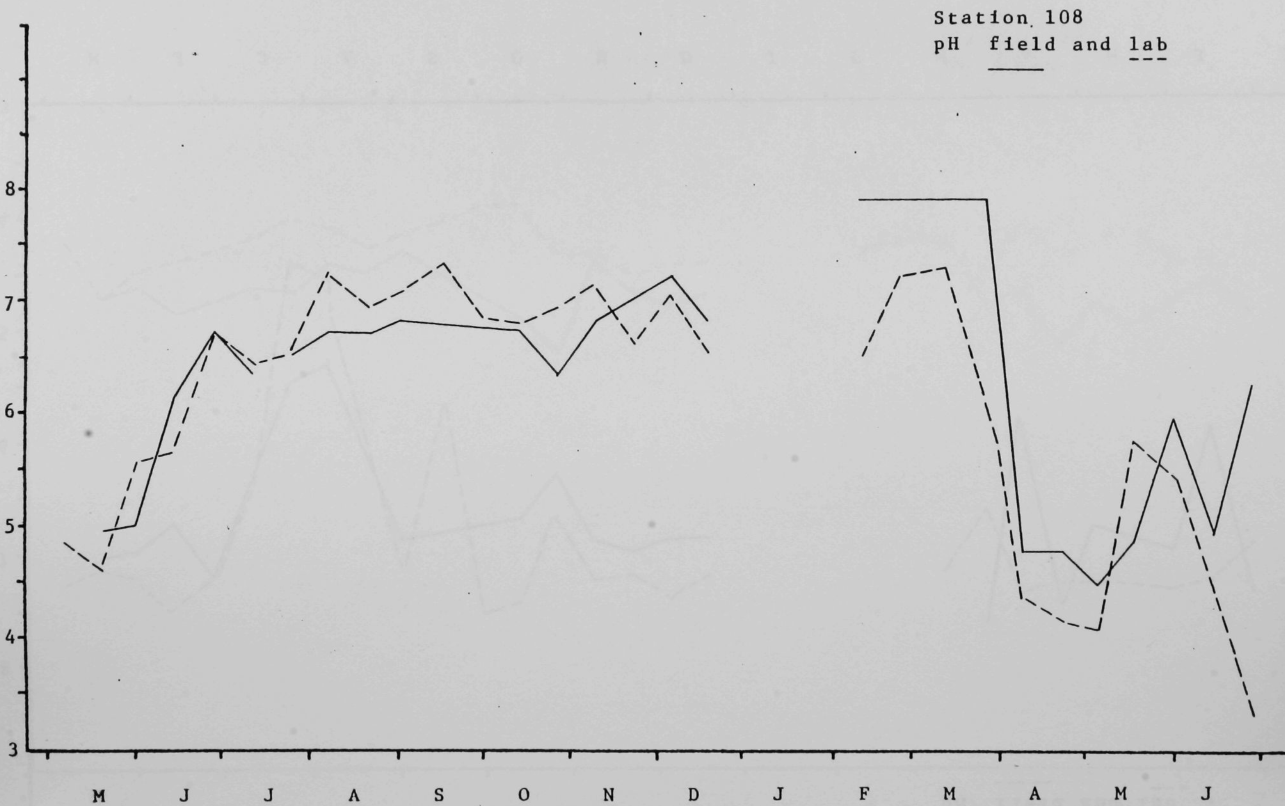


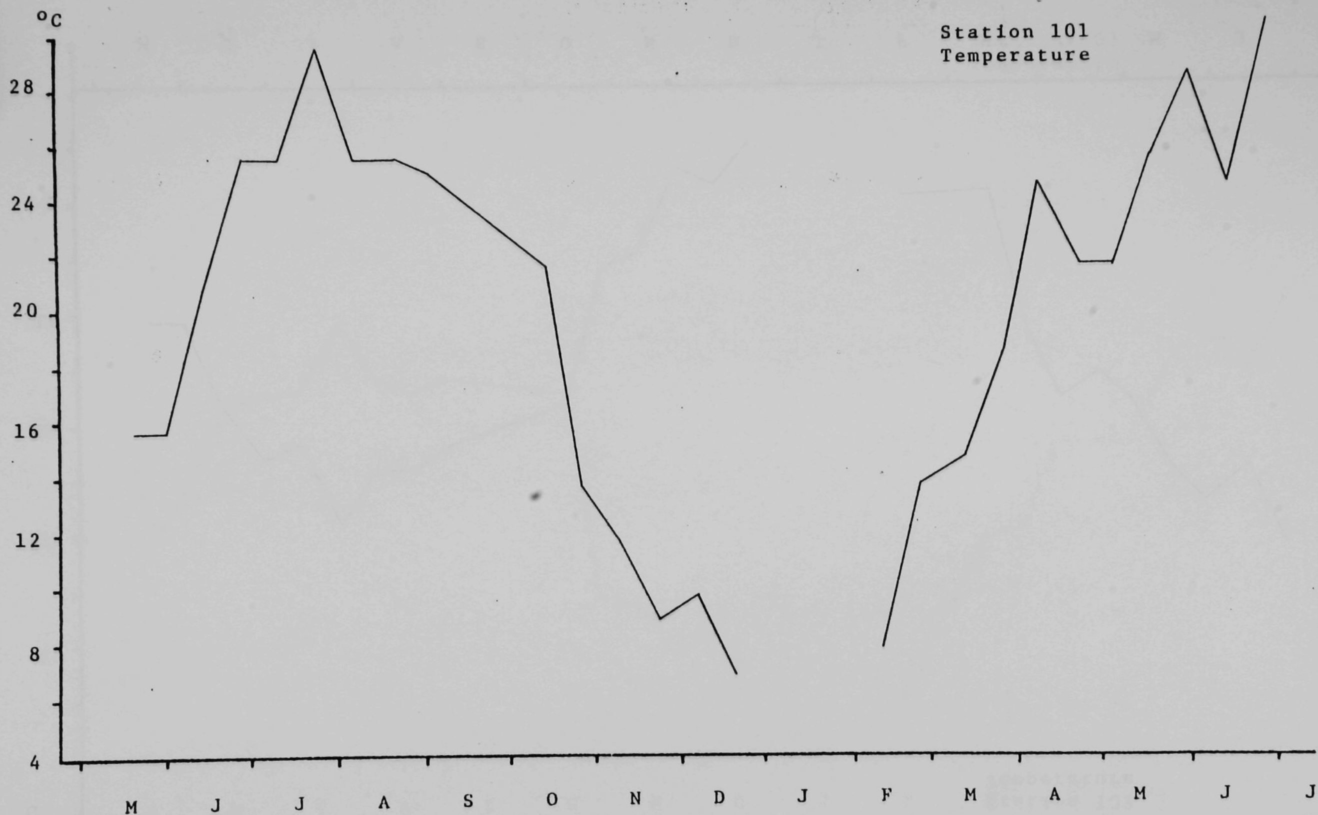
92


Station 105
pH . field and lab
9
8
7
6
5
4
3
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

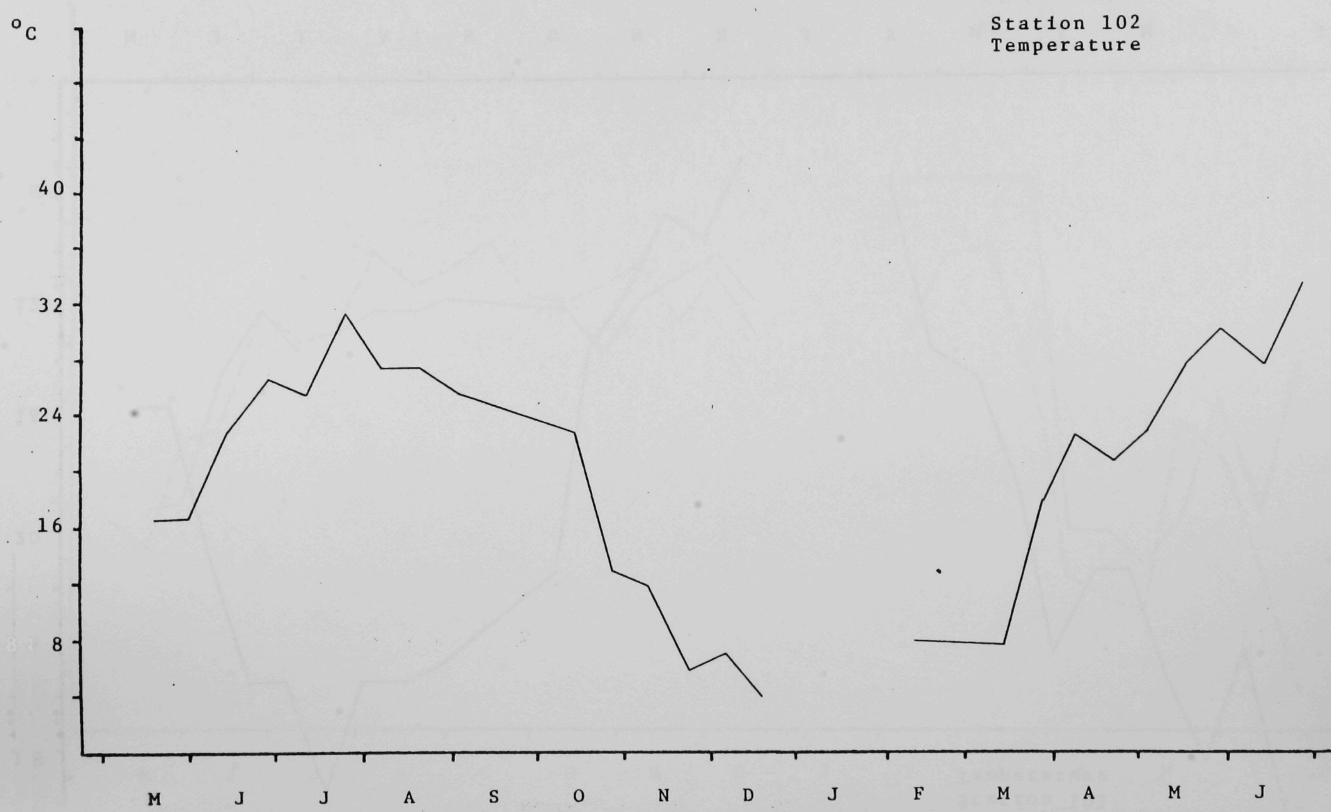

Station 106
pH field and lab
8
7
6
5
4
3
M
J
J
A
S
O
N
D
J
F
M
A
M
J

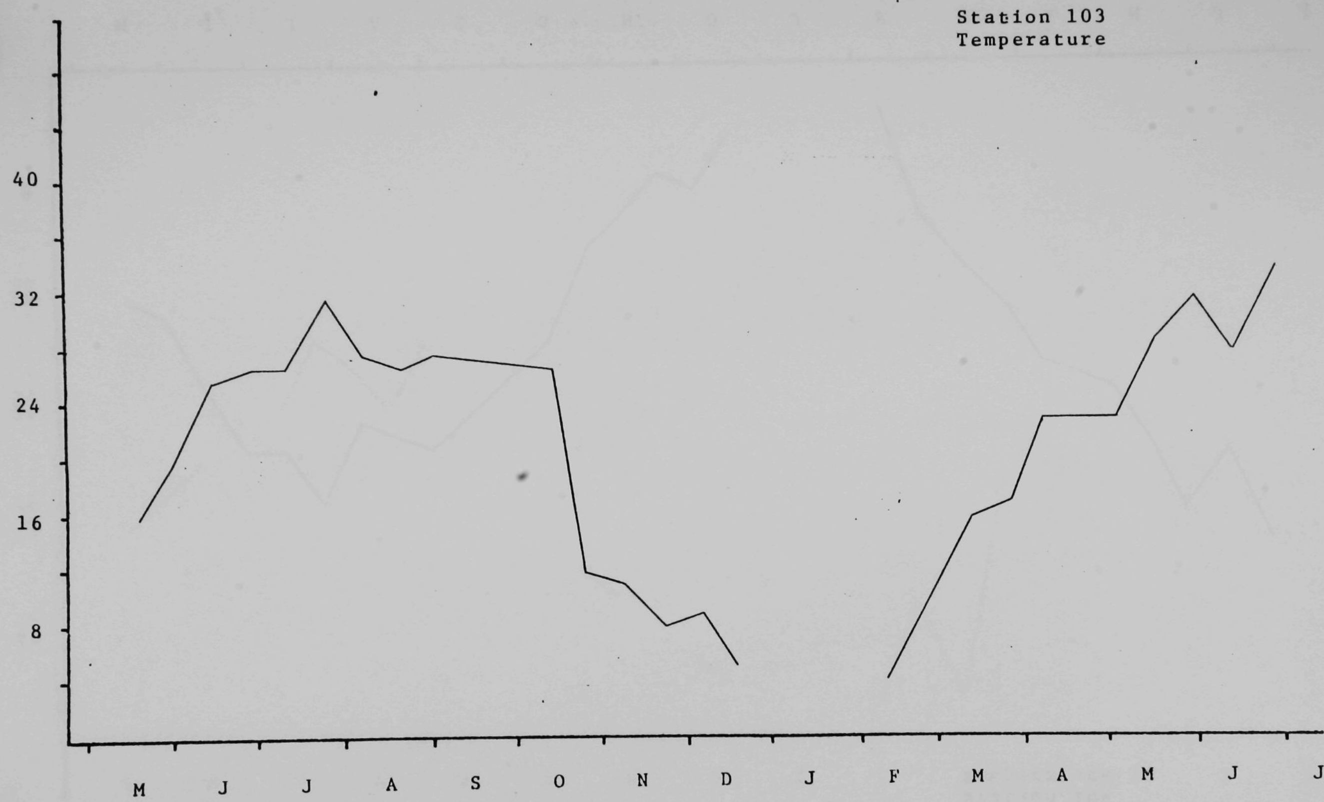

Station 107
pH field and lab
8
7
6
5
4
3
M J J A S O N D J F M A M J J


Station 108
pH field and lab
8
7
6
5
4
3
M J J A S O N D J F M A M J

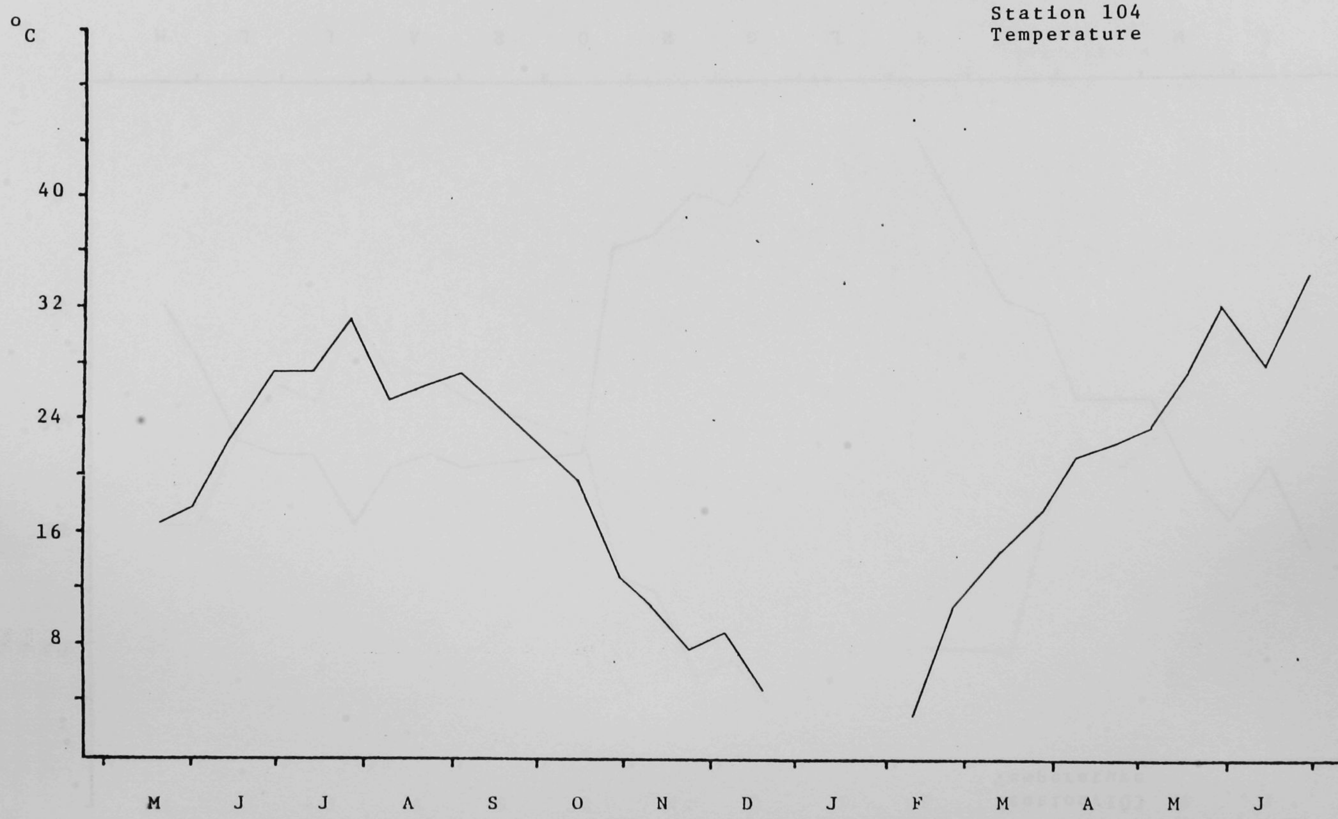


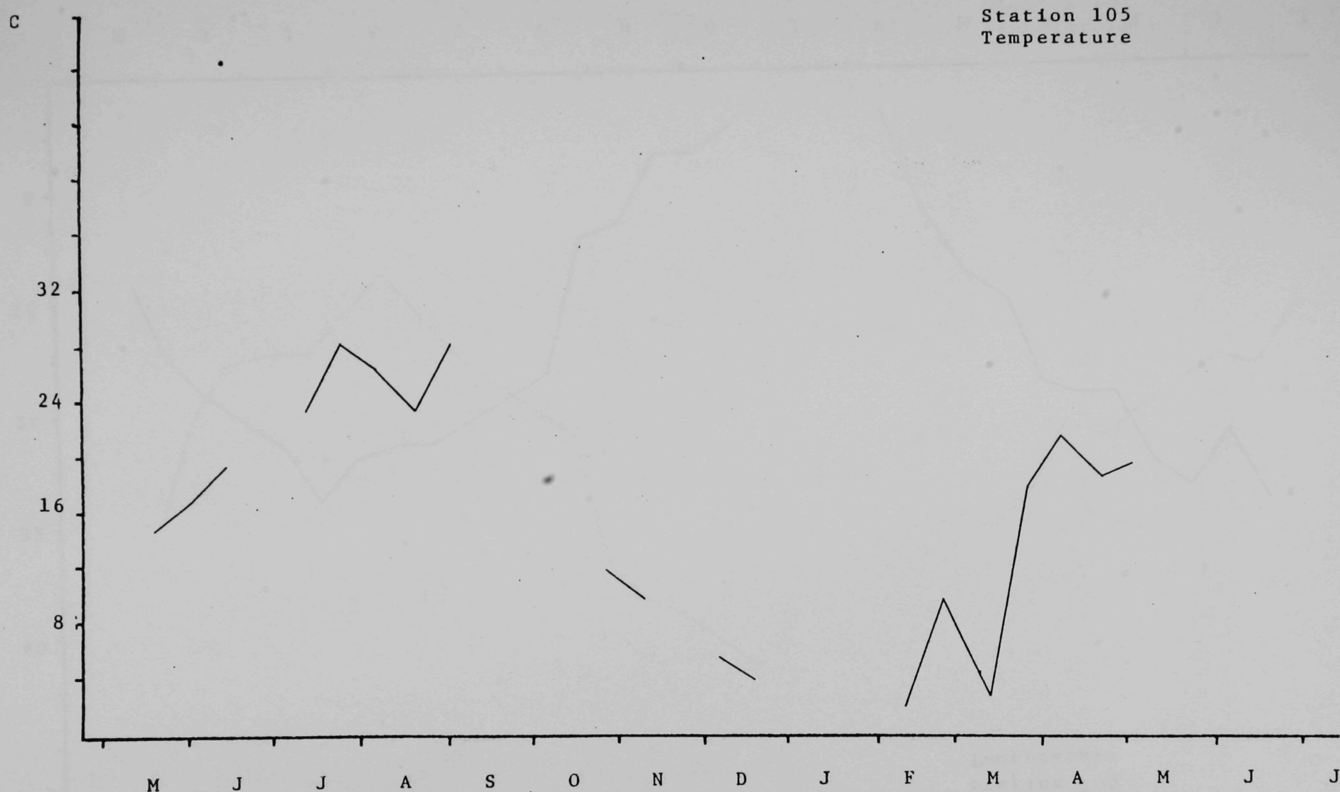
°C
Station 101
Temperature
28
24
20
16
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

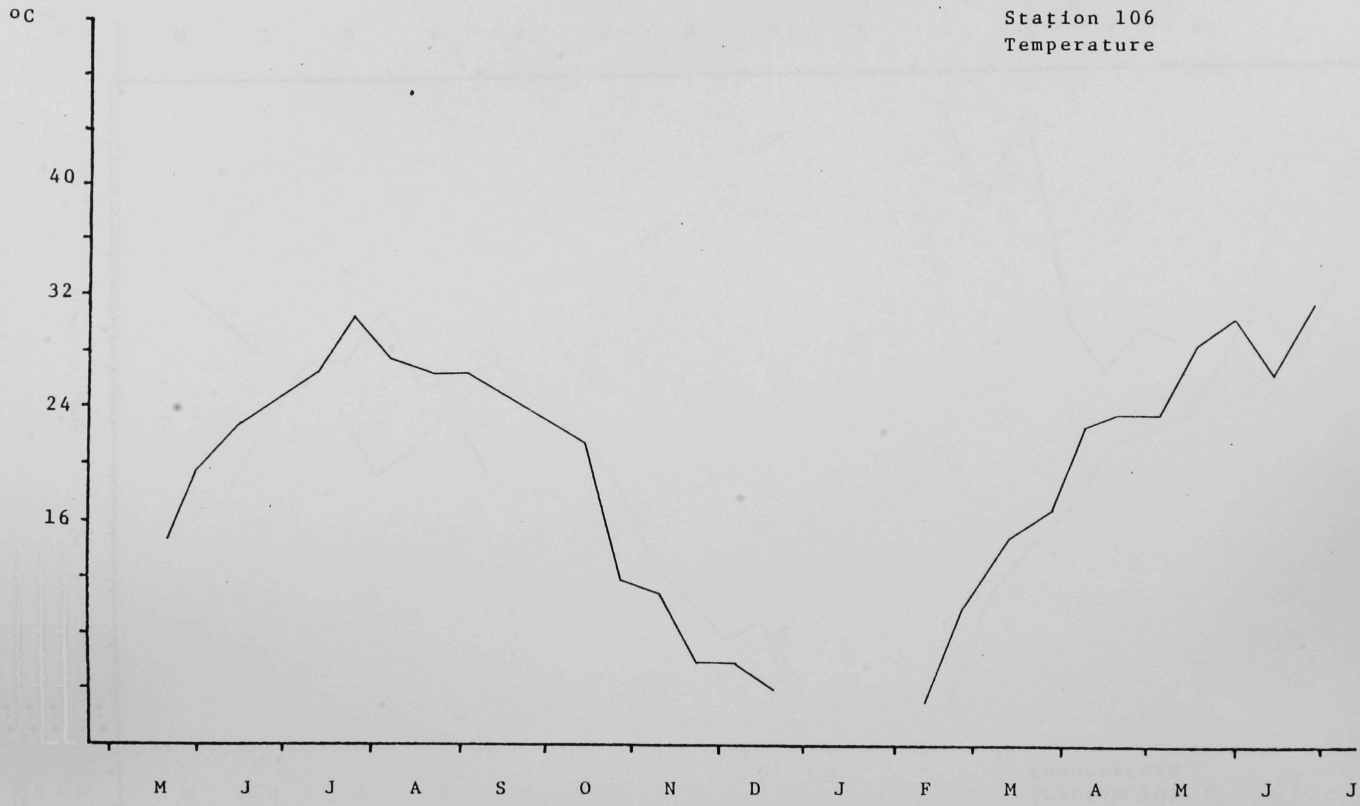

Station 102
Temperature
°C
40
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J



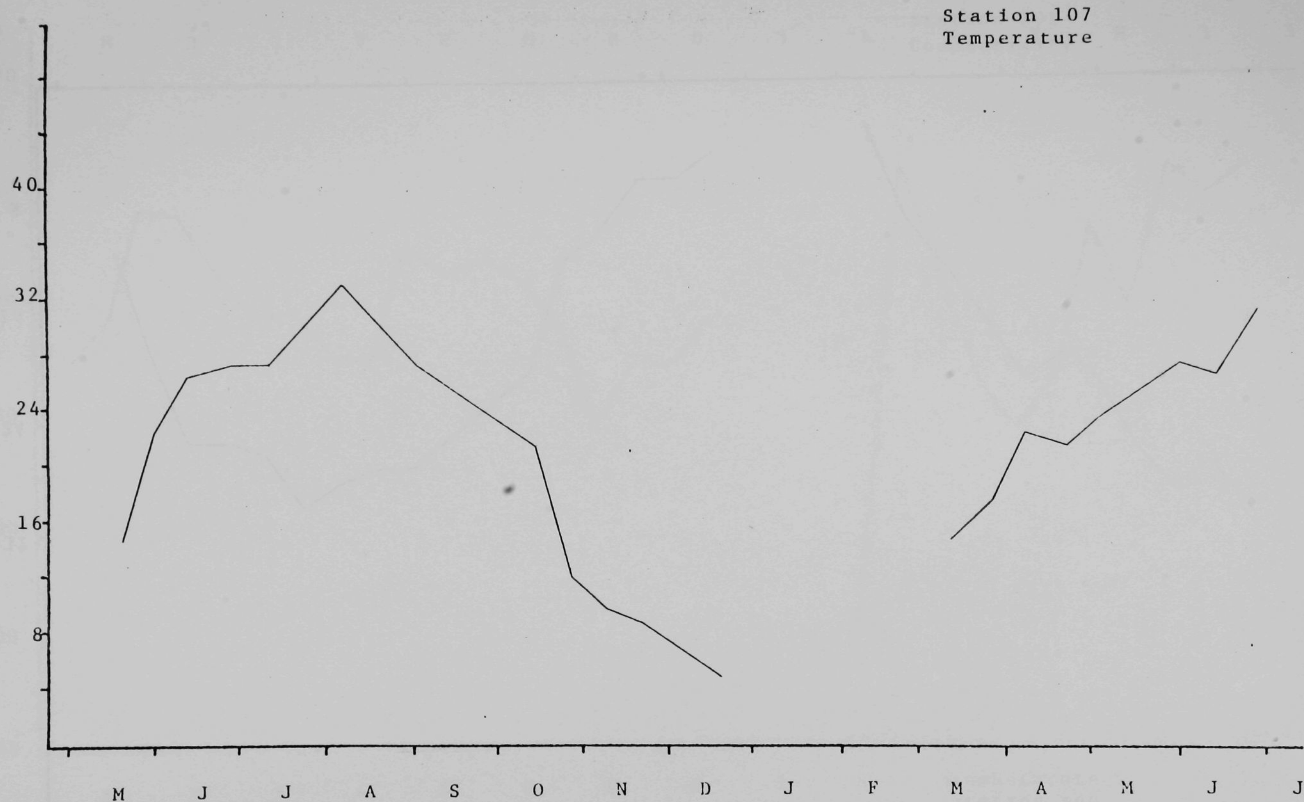
Station 103
Temperature
40
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

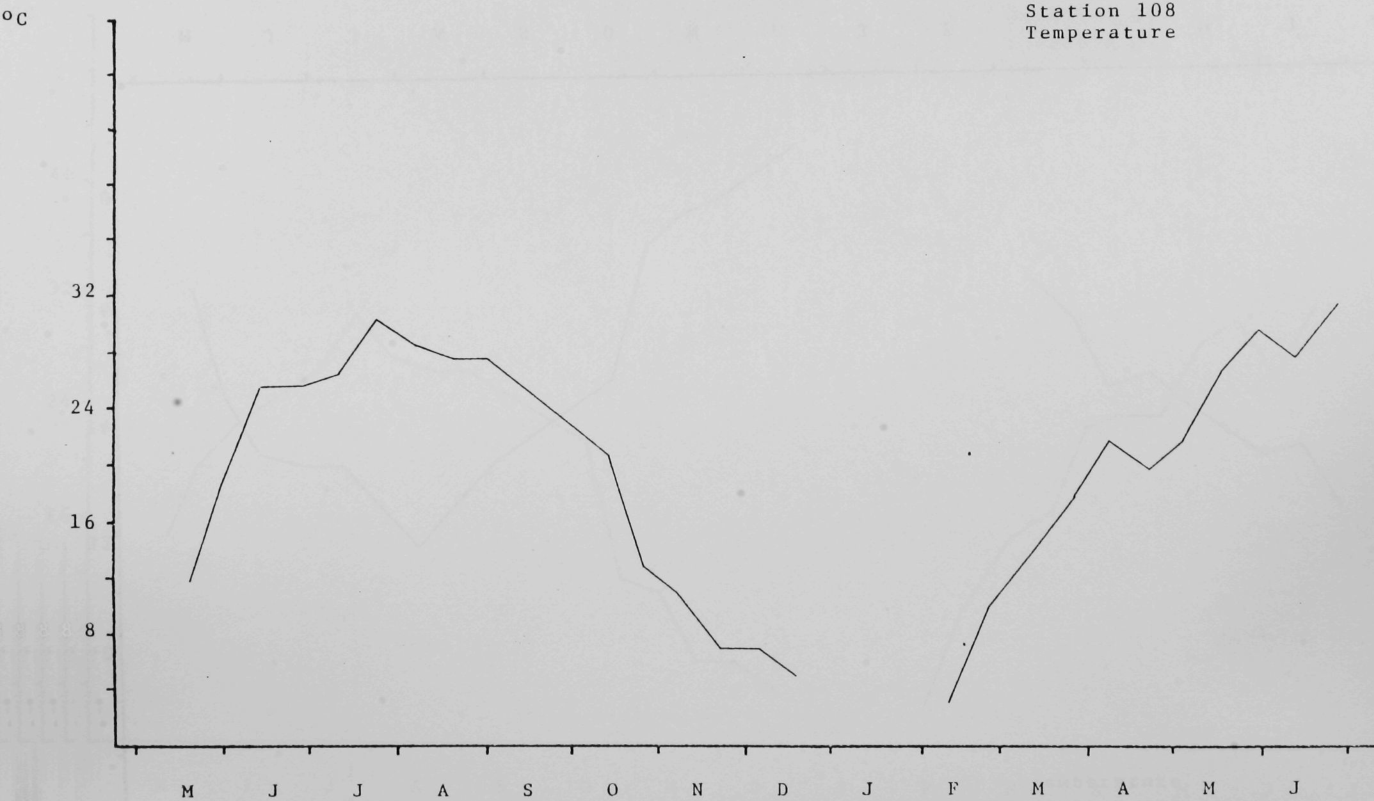

Station 104
Temperature
°C
40
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J


Station 105
Temperature
C
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

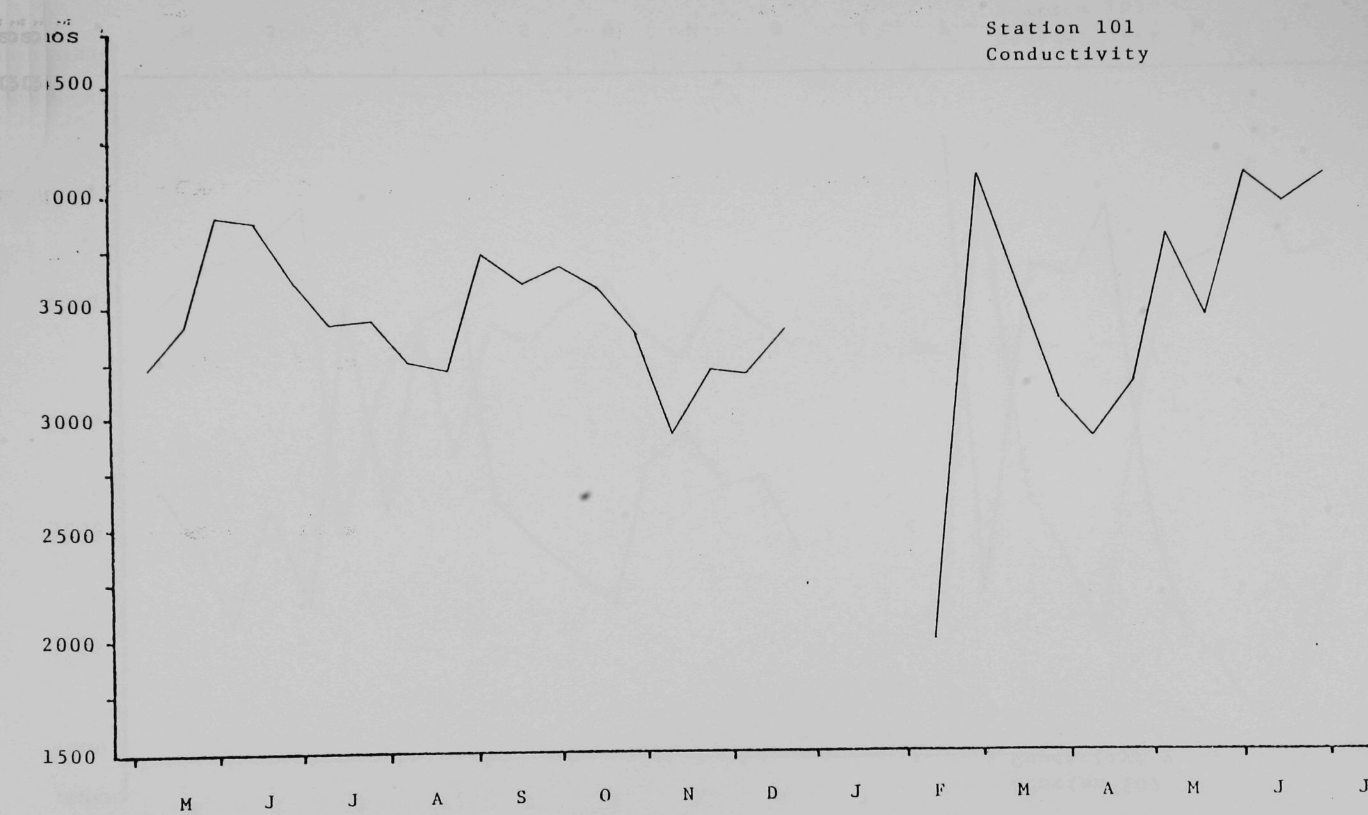


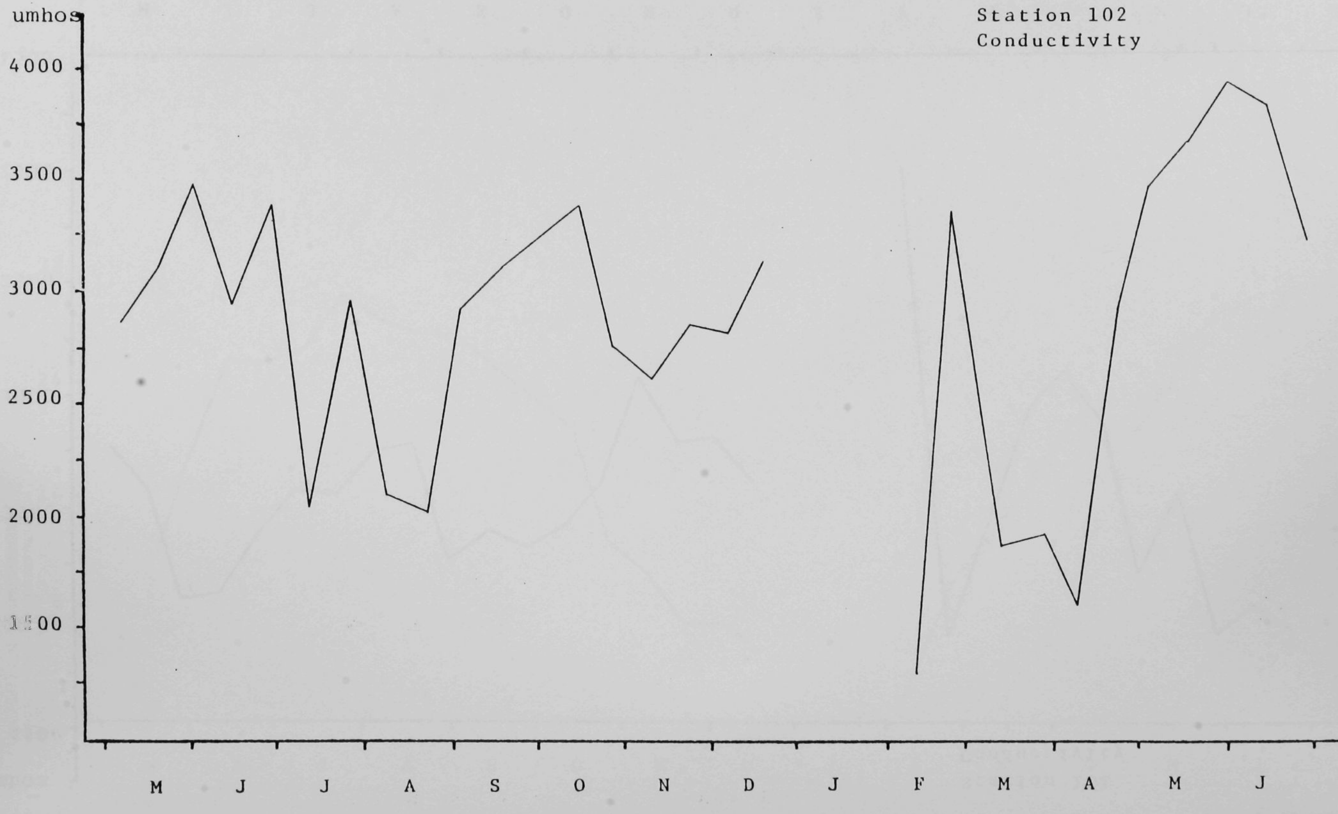
Station 106
Temperature
oC
40
32
24
16
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 107
Temperature
40
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



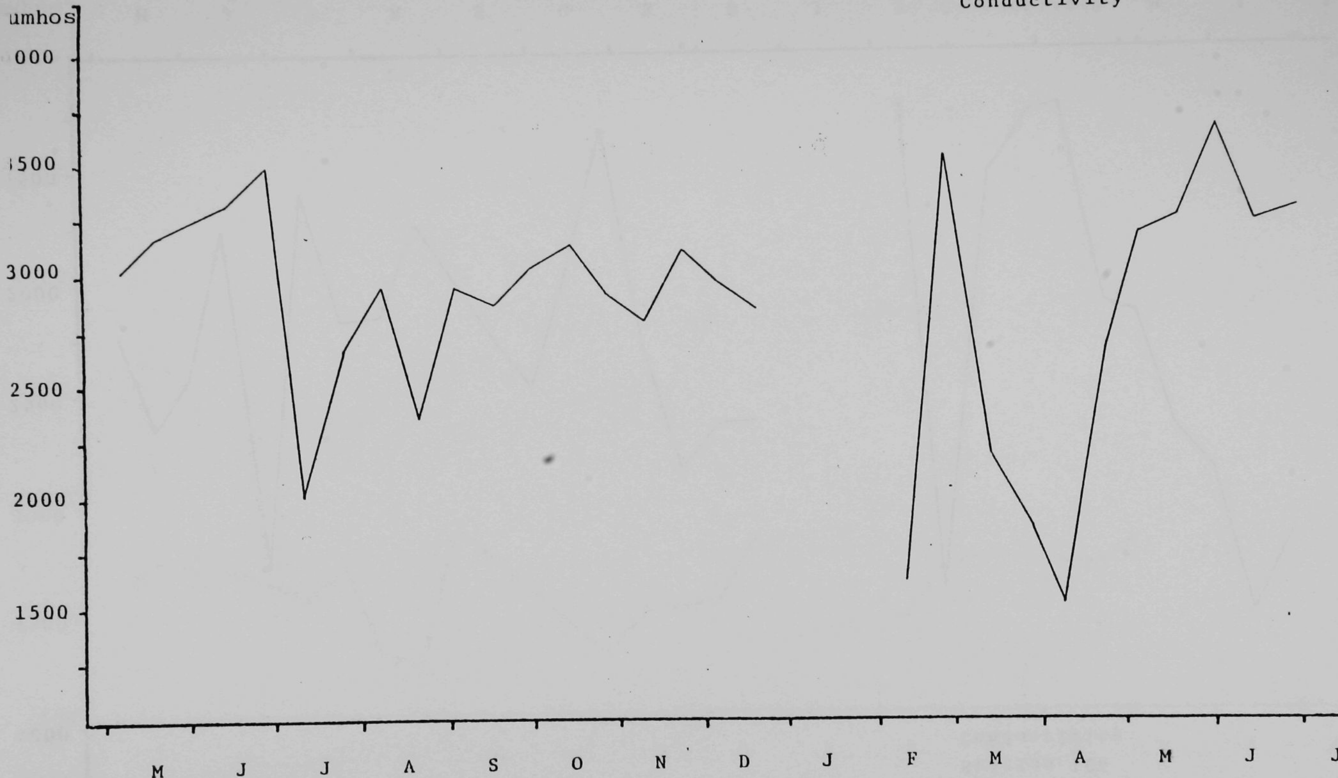
Station 108
Temperature
°C
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J

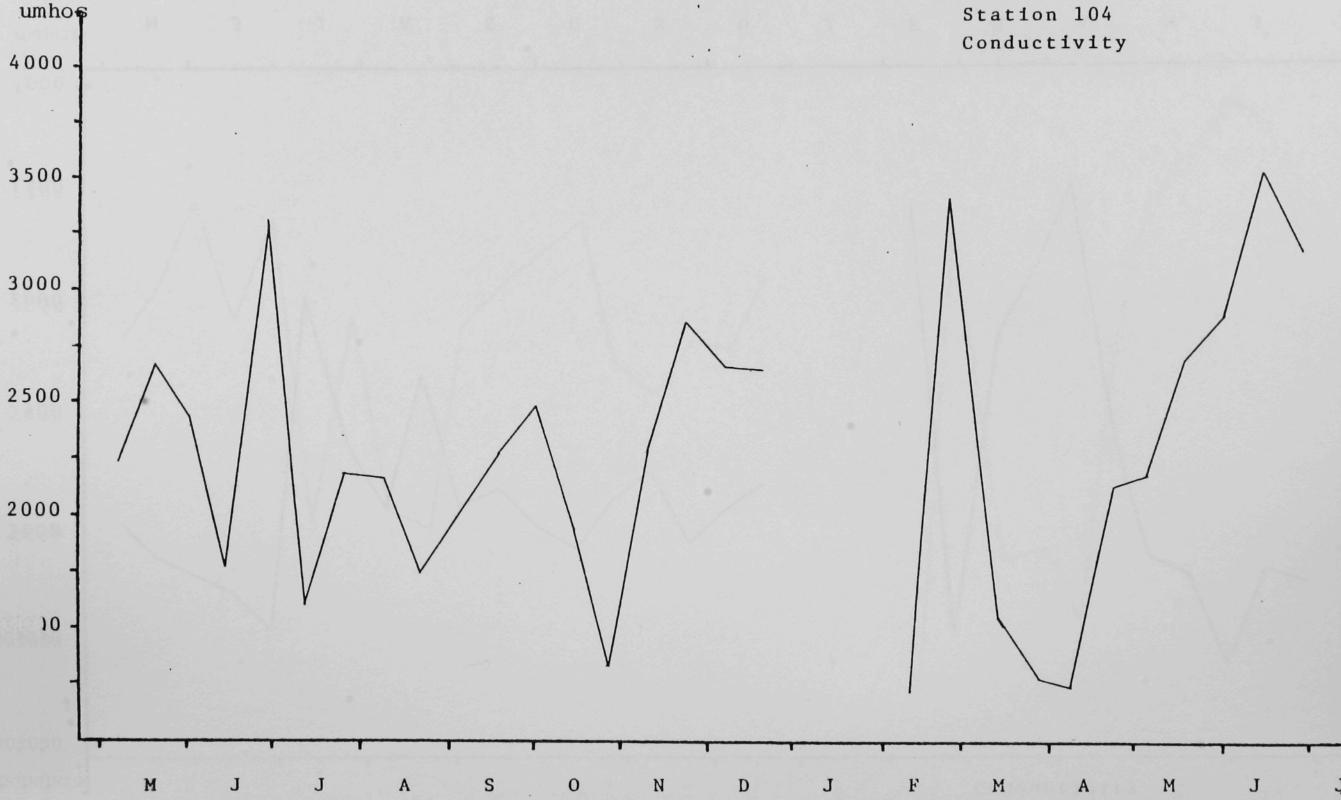

Station 101
Conductivity
nos
500
000
3500
3000
2500
2000
1500
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



umhos
Station 102
Conductivity
4000
3500
3000
2500
2000
1500
M
J
J
A
S
O
N
D
J
F
M
A
M
J

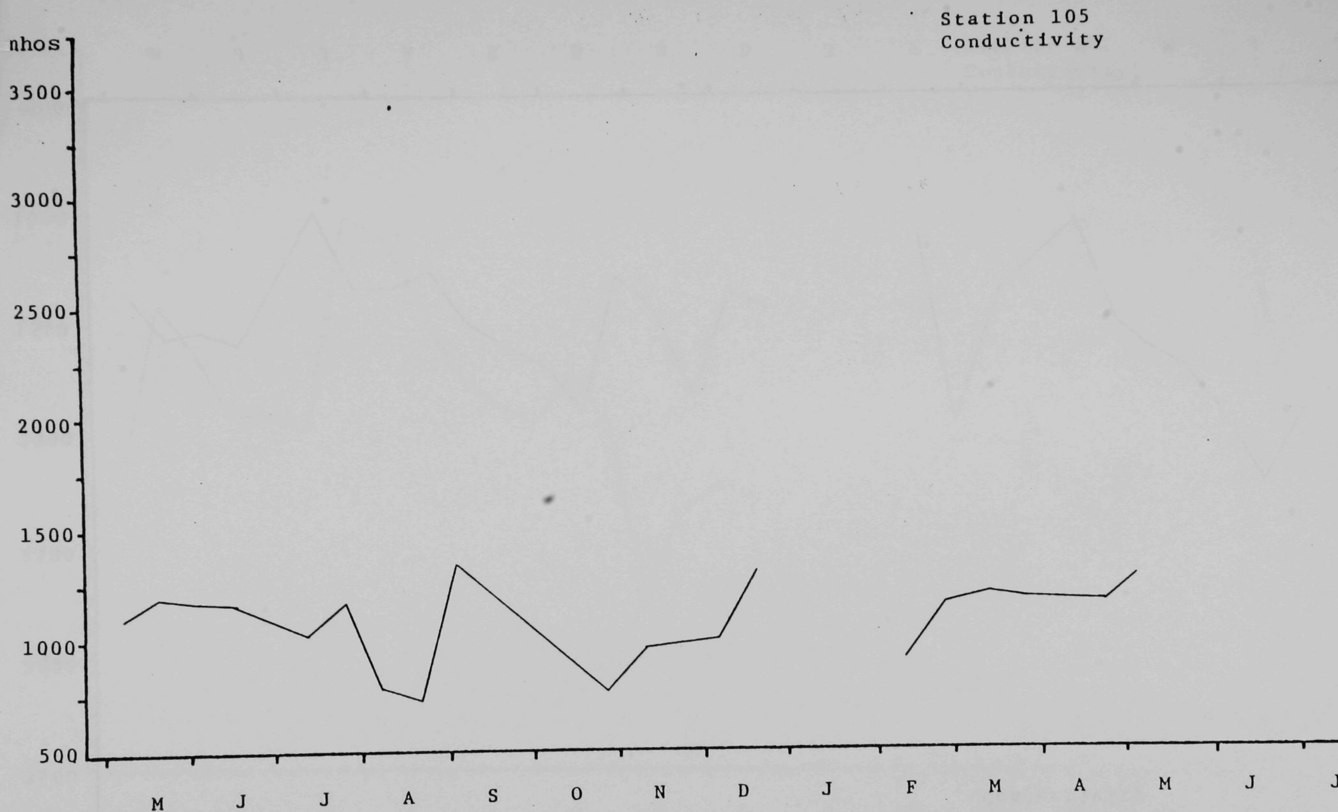
Station 103
Conductivity

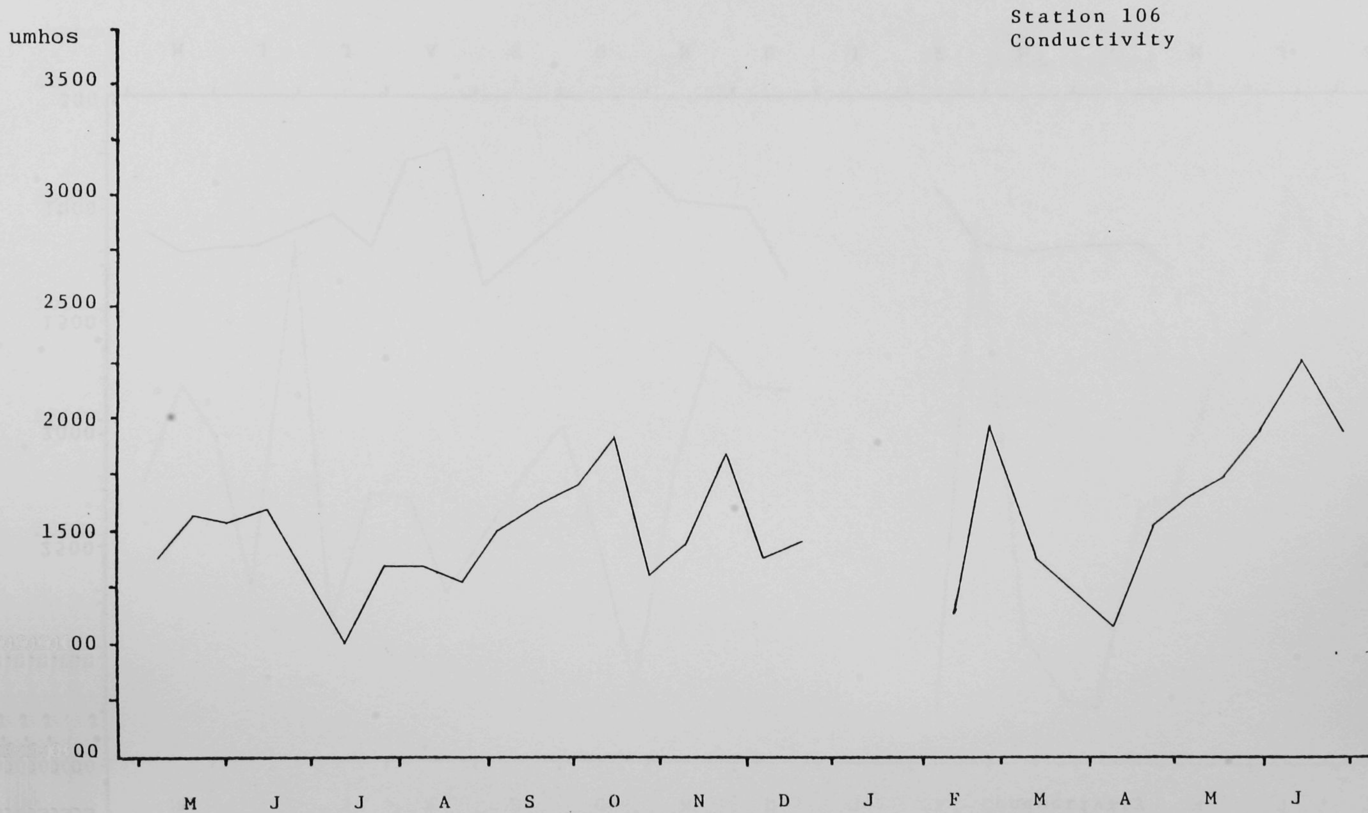


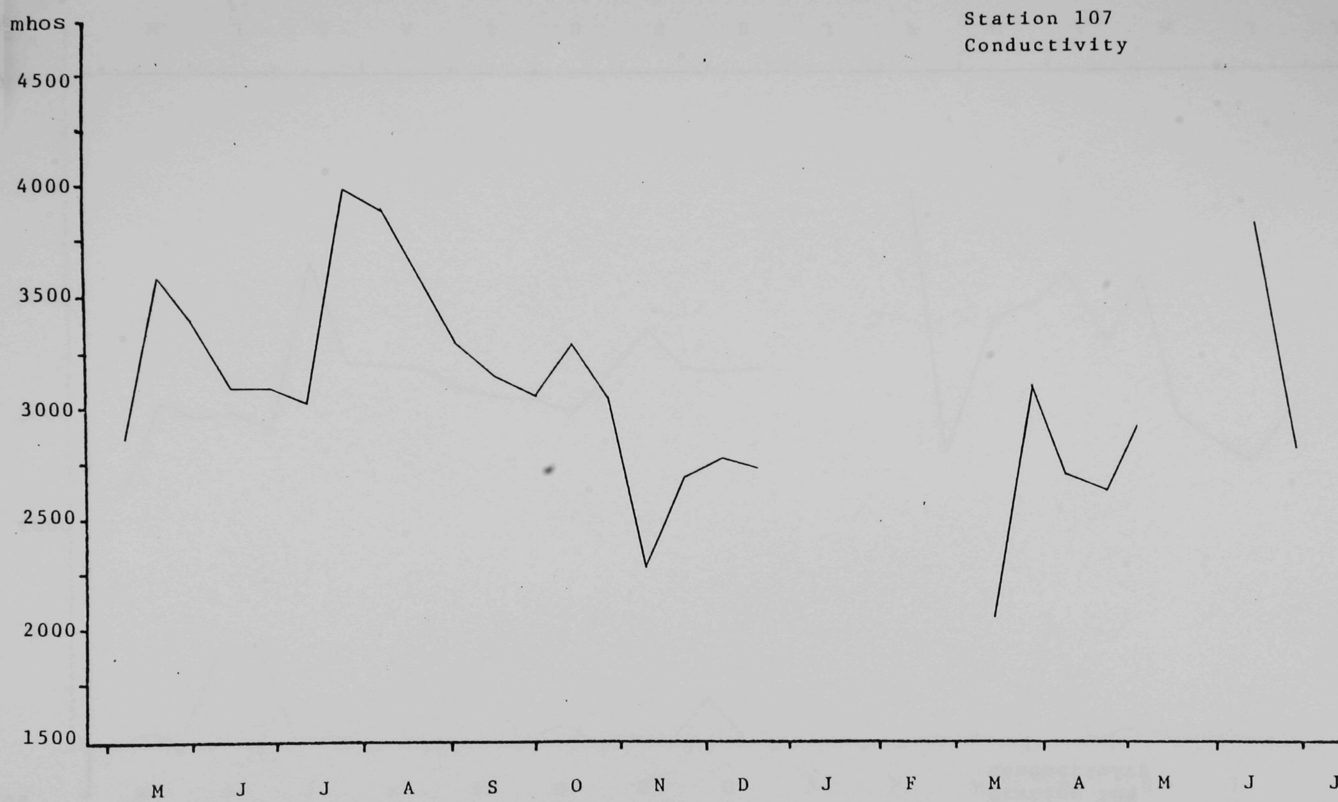


umhos
Station 104
Conductivity
4000
3500
3000
2500
2000
)0
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

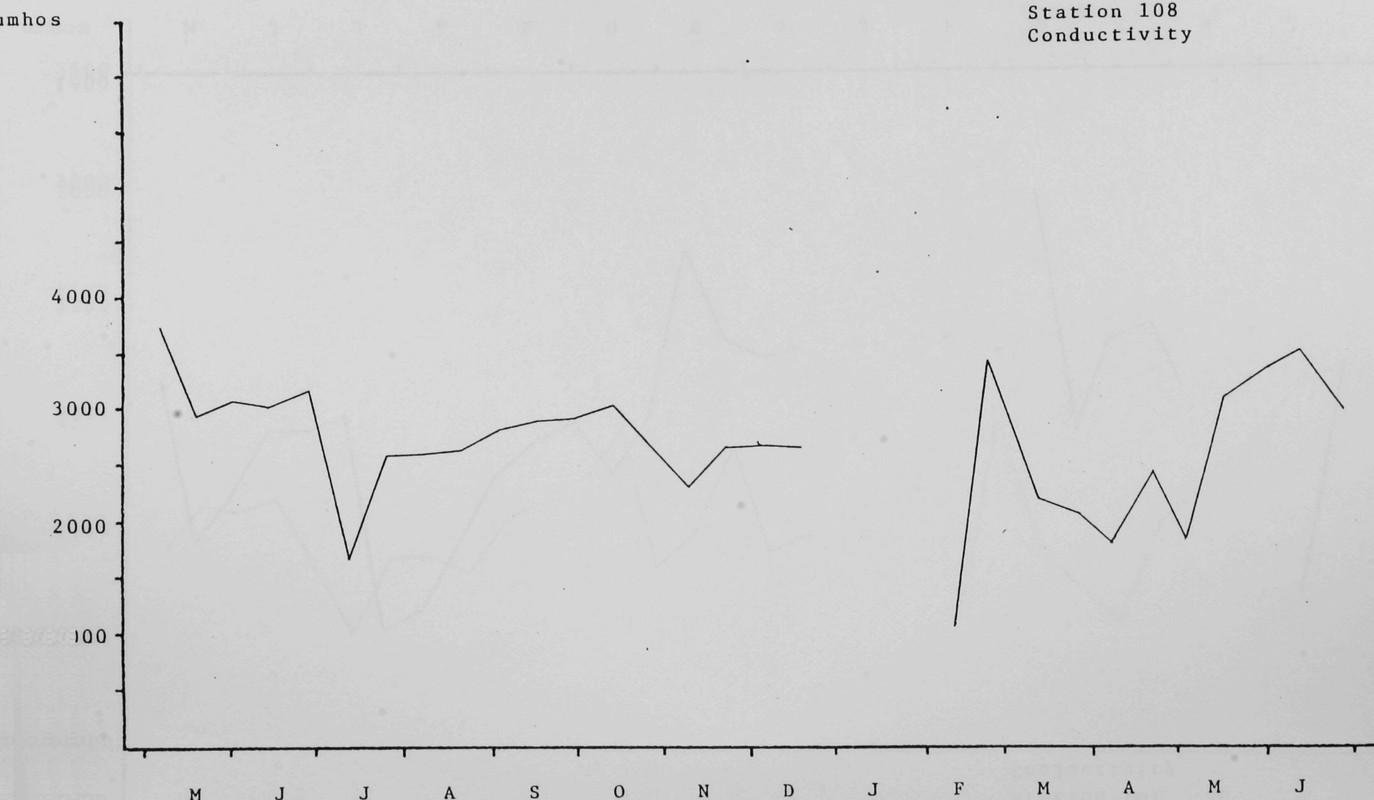
108


Station 105
Conductivity
mhos
3500
3000
2500
2000
1500
1000
500
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 106
Conductivity
umhos
3500
3000
2500
2000
1500
00
00
M
J
J
A
S
O
N
D
J
F
M
A
M
J

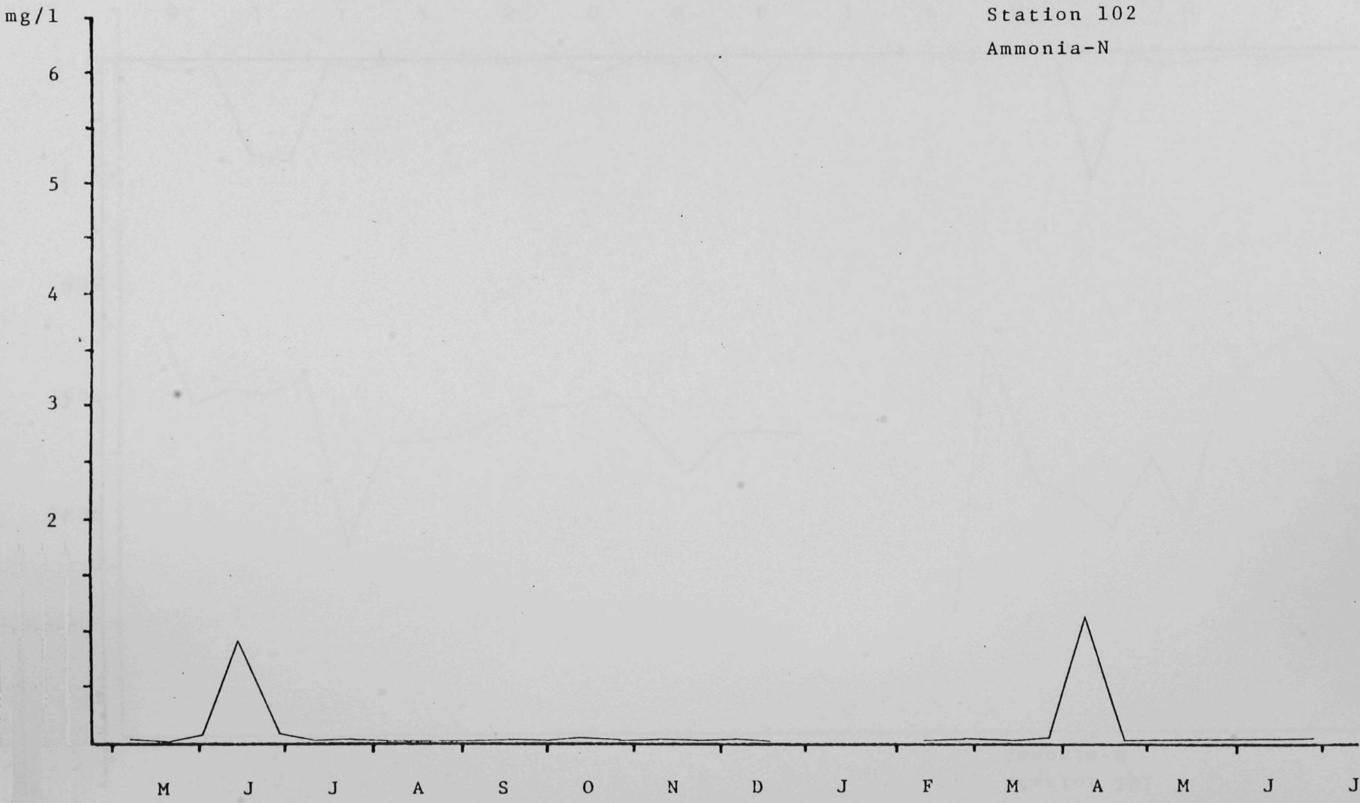

Station 107
Conductivity
mhos
4500
4000
3500
3000
2500
2000
1500
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

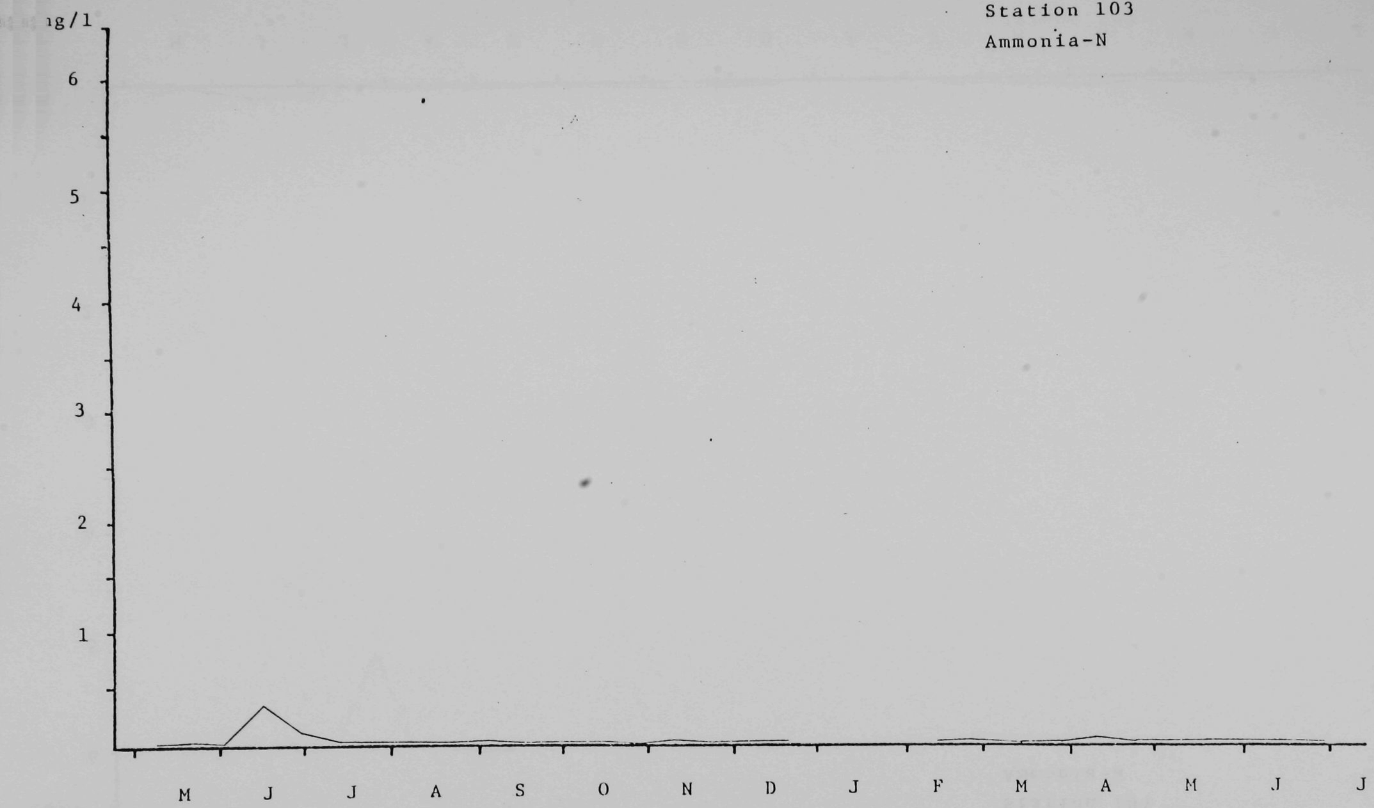
111

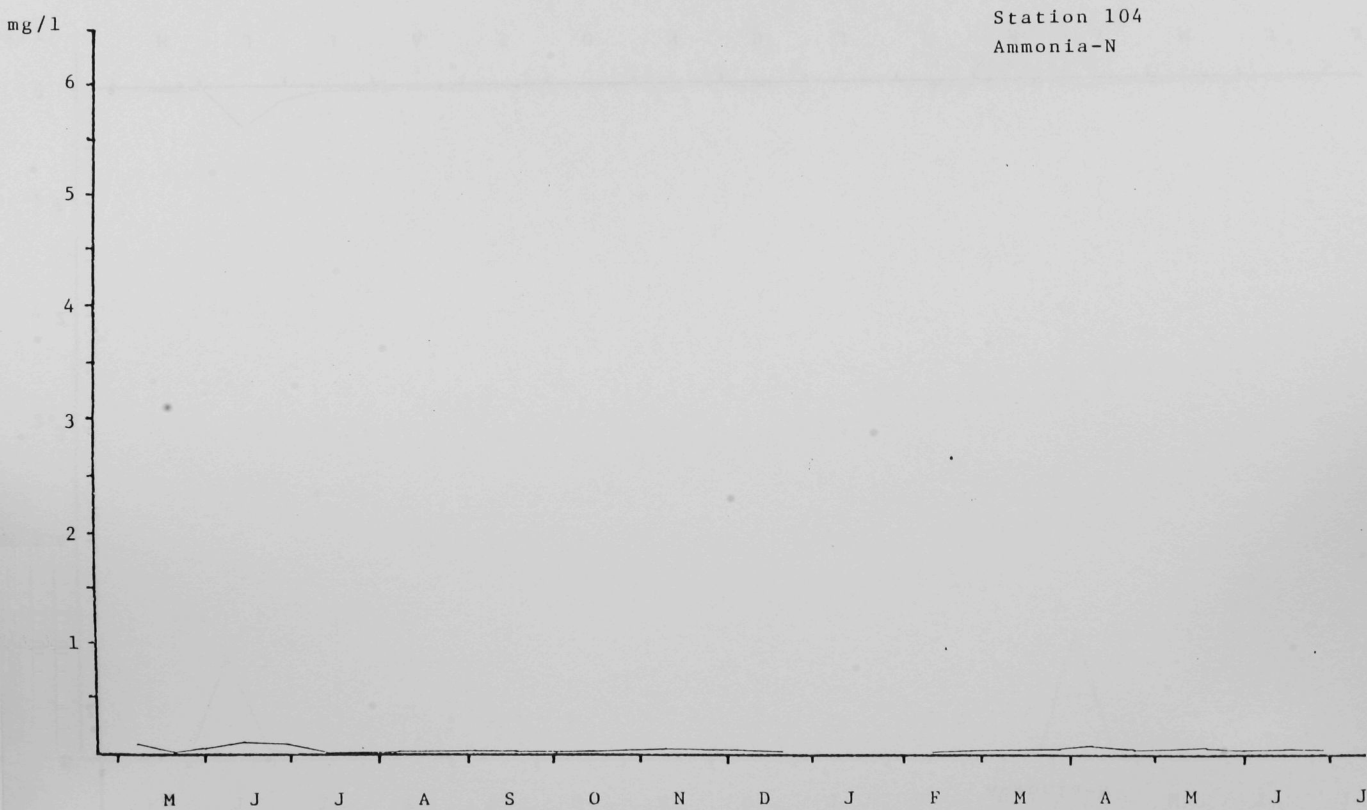


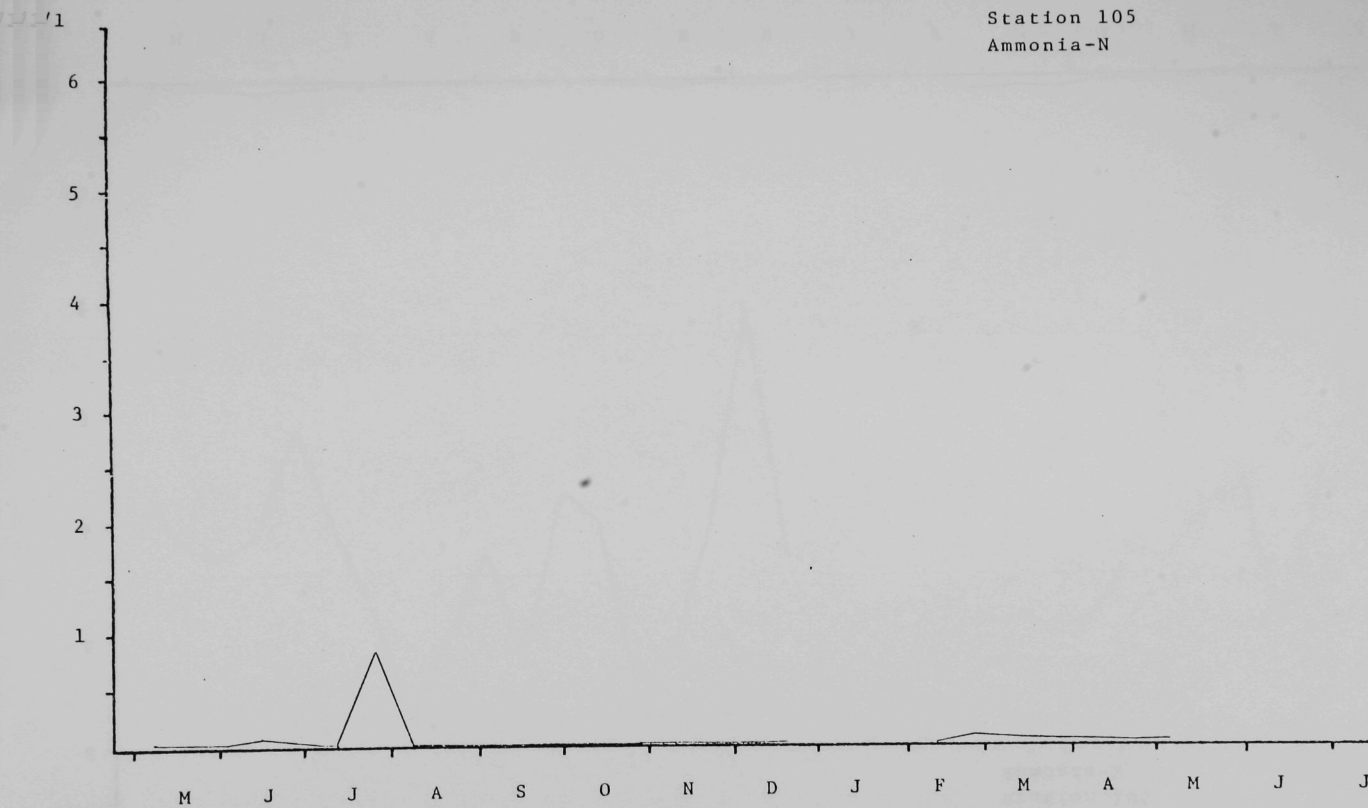
Station 108
Conductivity
umhos
4000
3000
2000
00
M
J
J
A
S
O
N
D
J
F
M
A
M
J


Station 101
Ammonia-N
6
5
4
3
2
1
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

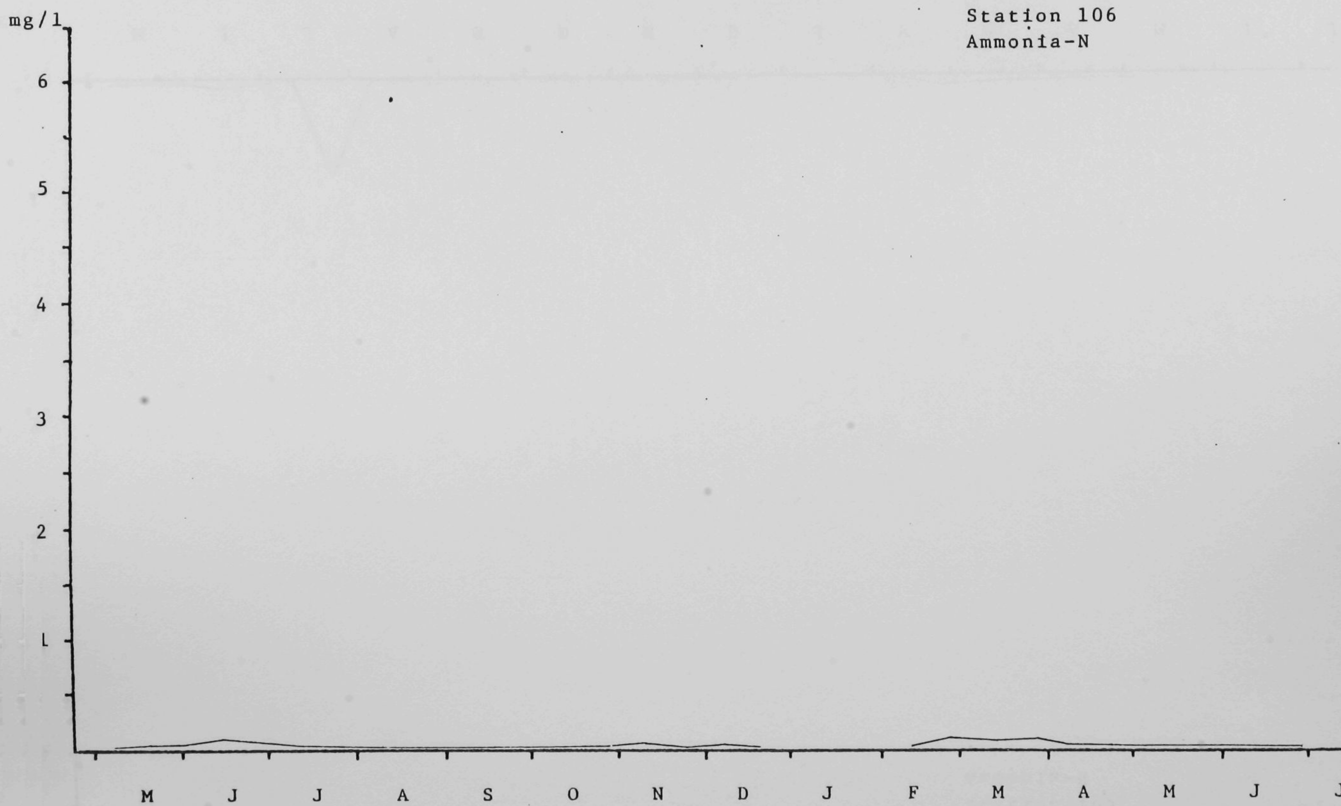

Station 102
Ammonia-N
mg/1
6
5
4
3
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

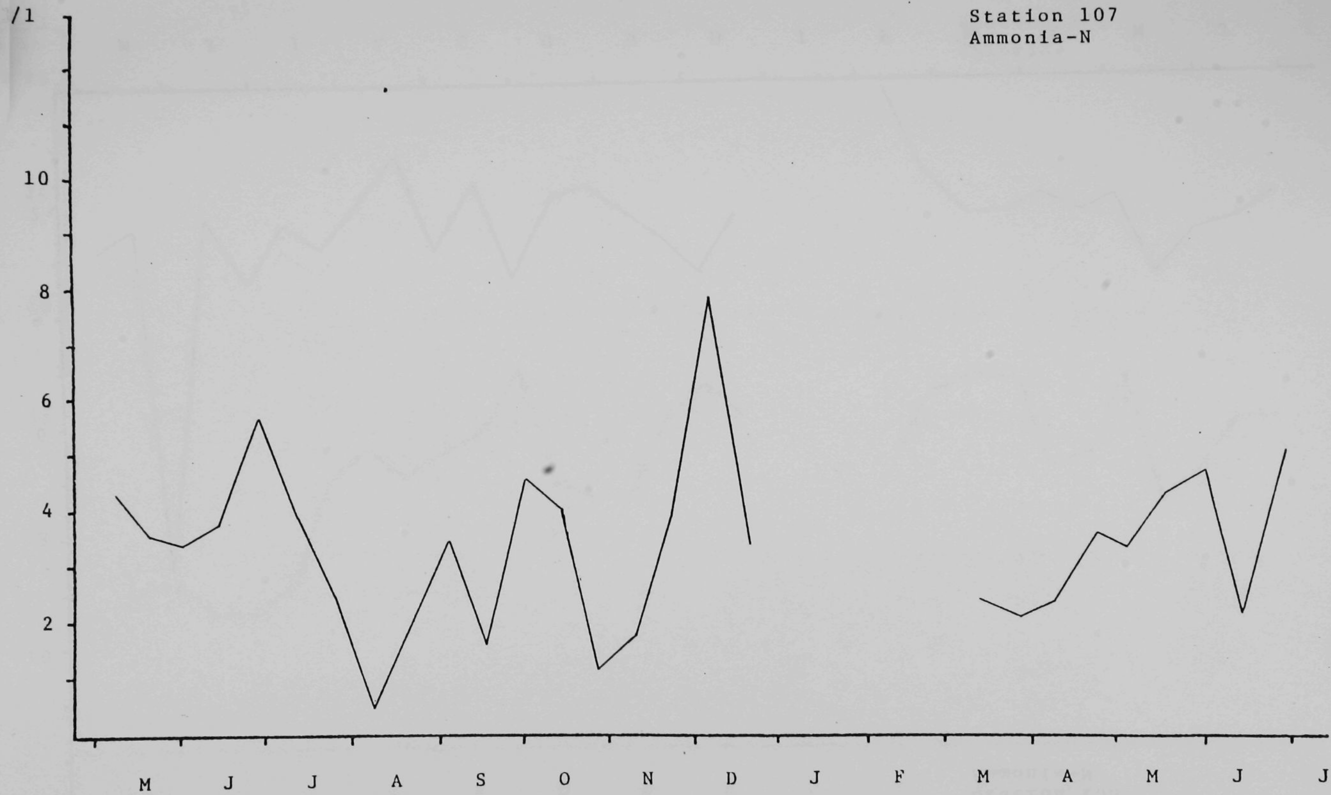

Station 103
Ammonia-N
mg/l
6
5
4
3
2
1
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

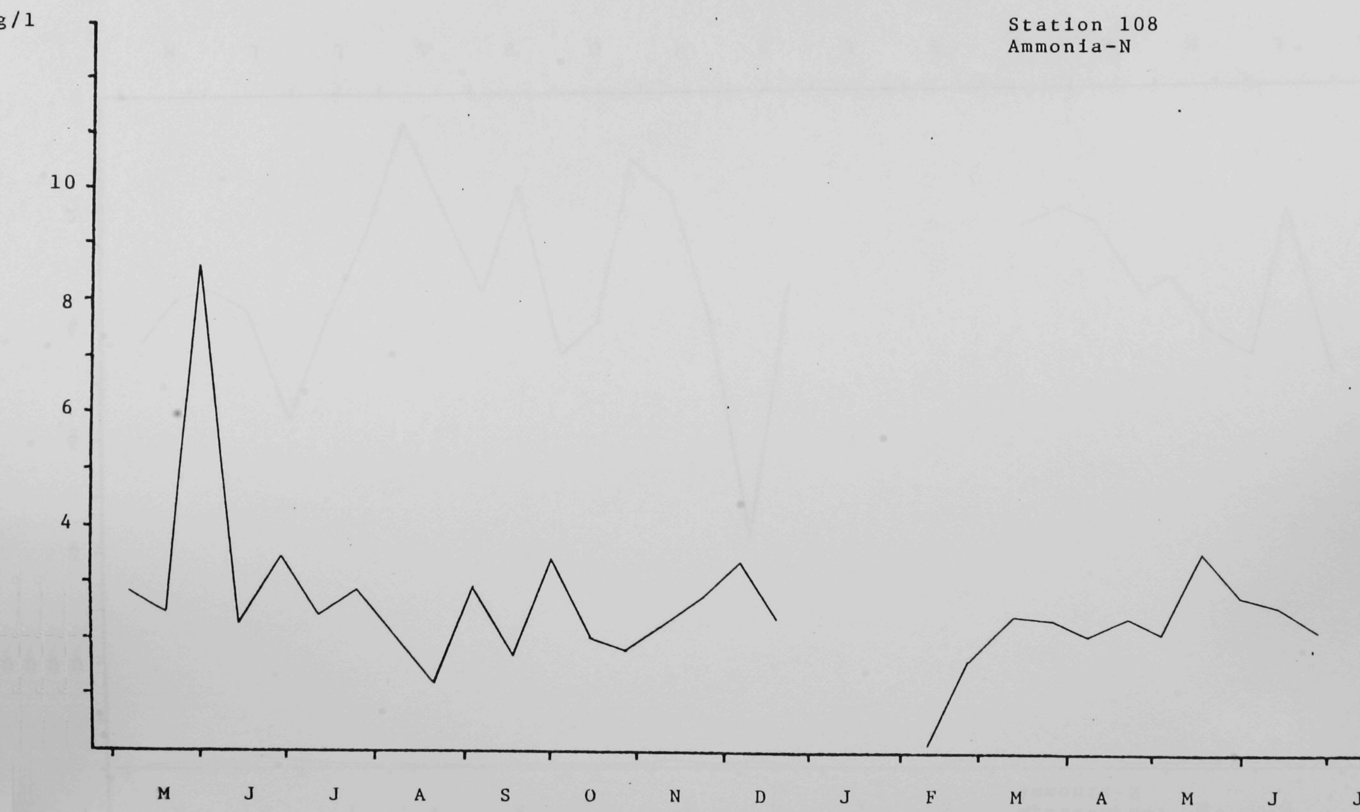

Station 104
Ammonia-N
mg/l
6
5
4
3
2
1
M J J A S O N D J F M A M J J



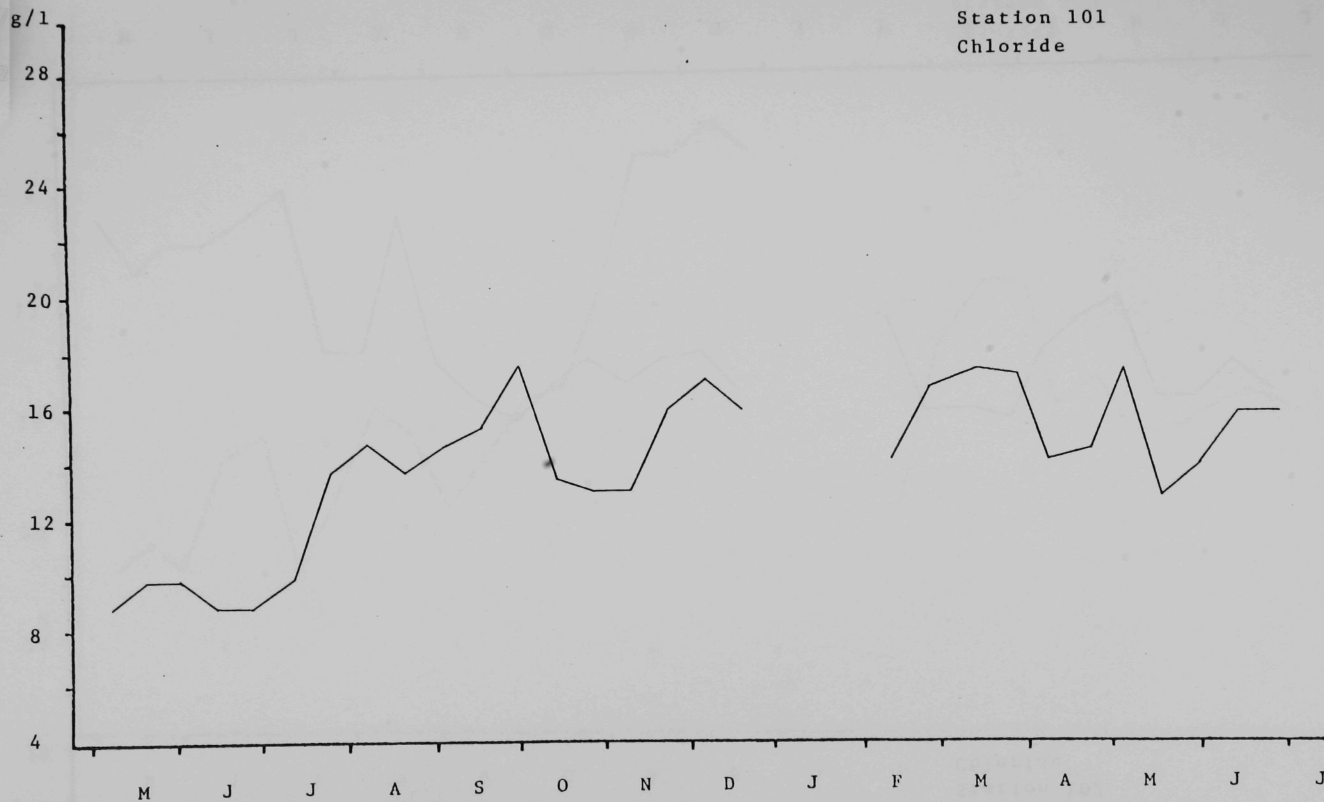
Station 105
Ammonia-N
'1
6
5
4
3
2
1
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 106
Ammonia-N
mg/1
6
5
4
3
2
1
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

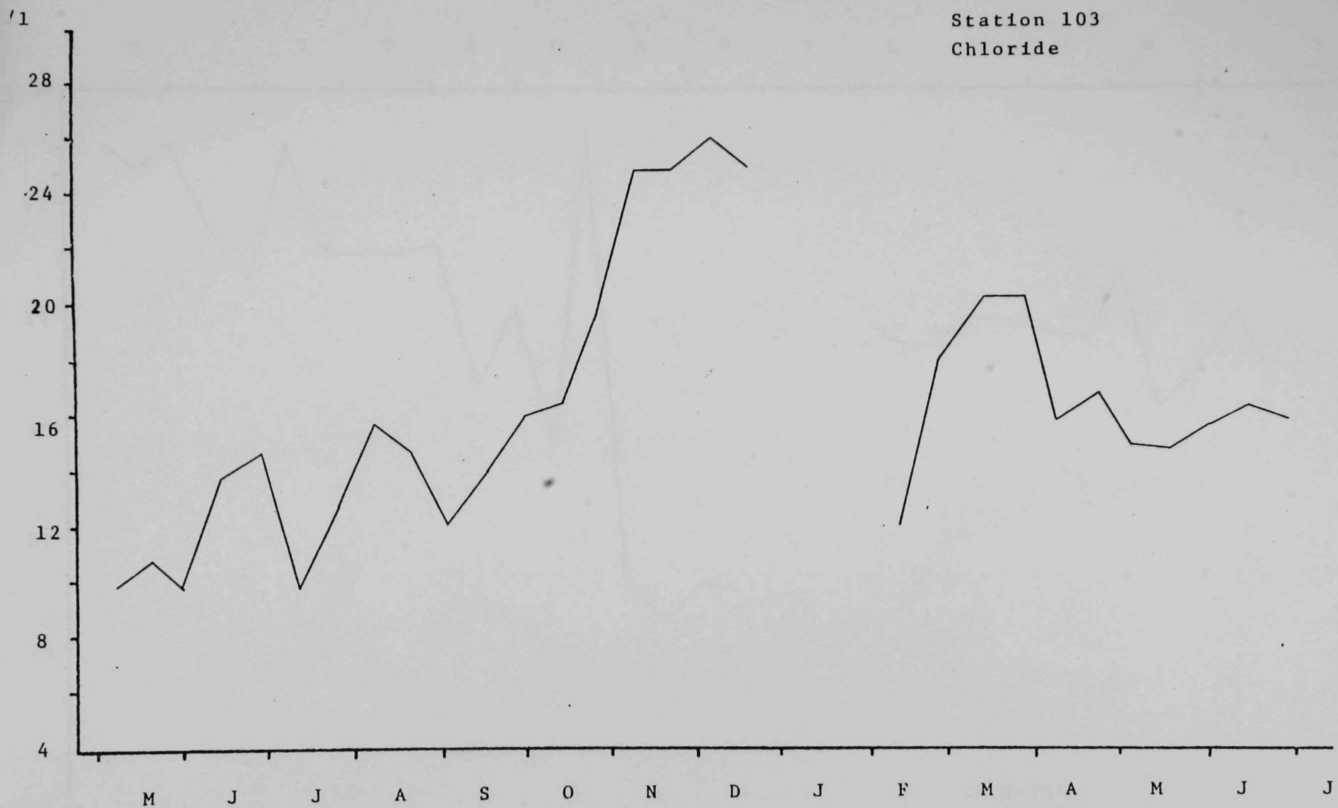

Station 107
Ammonia-N
/1
10
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



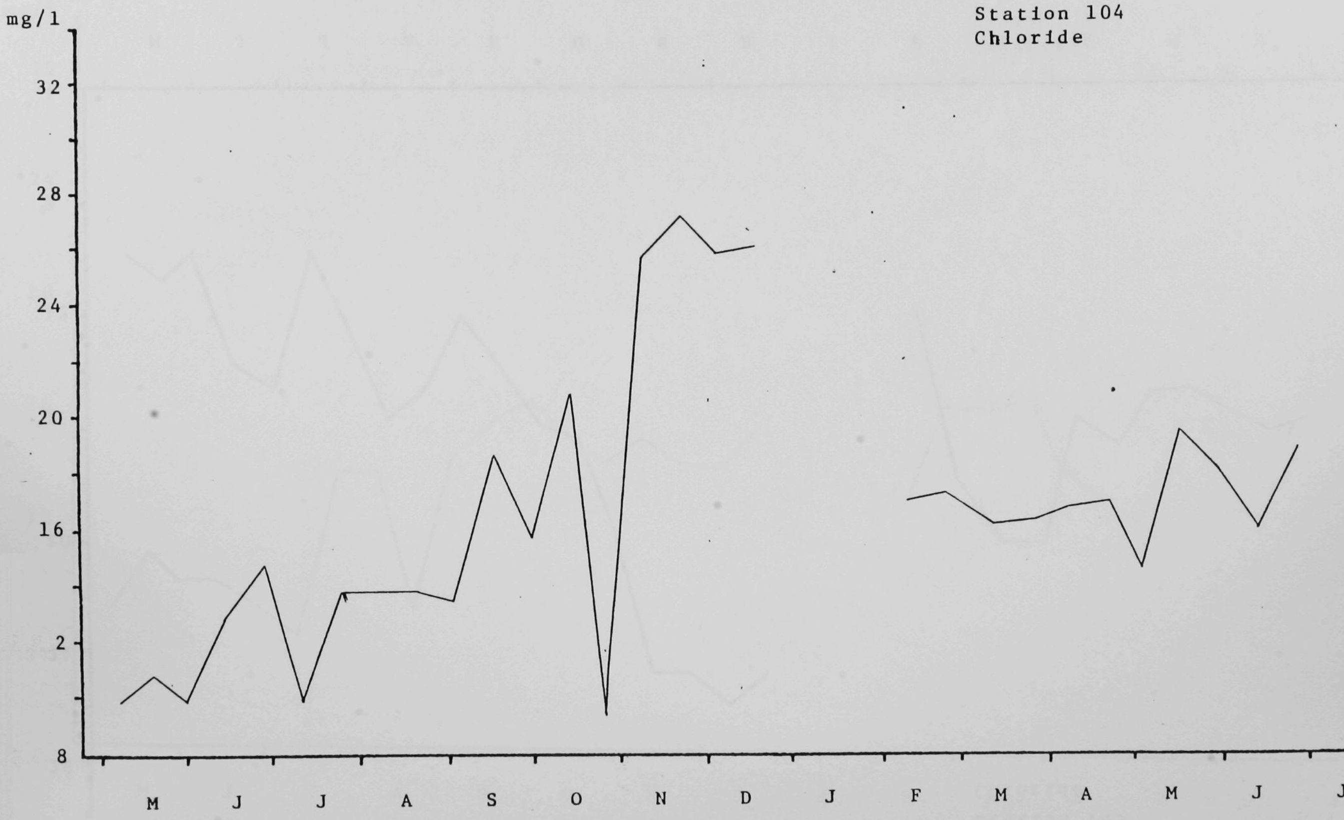
120

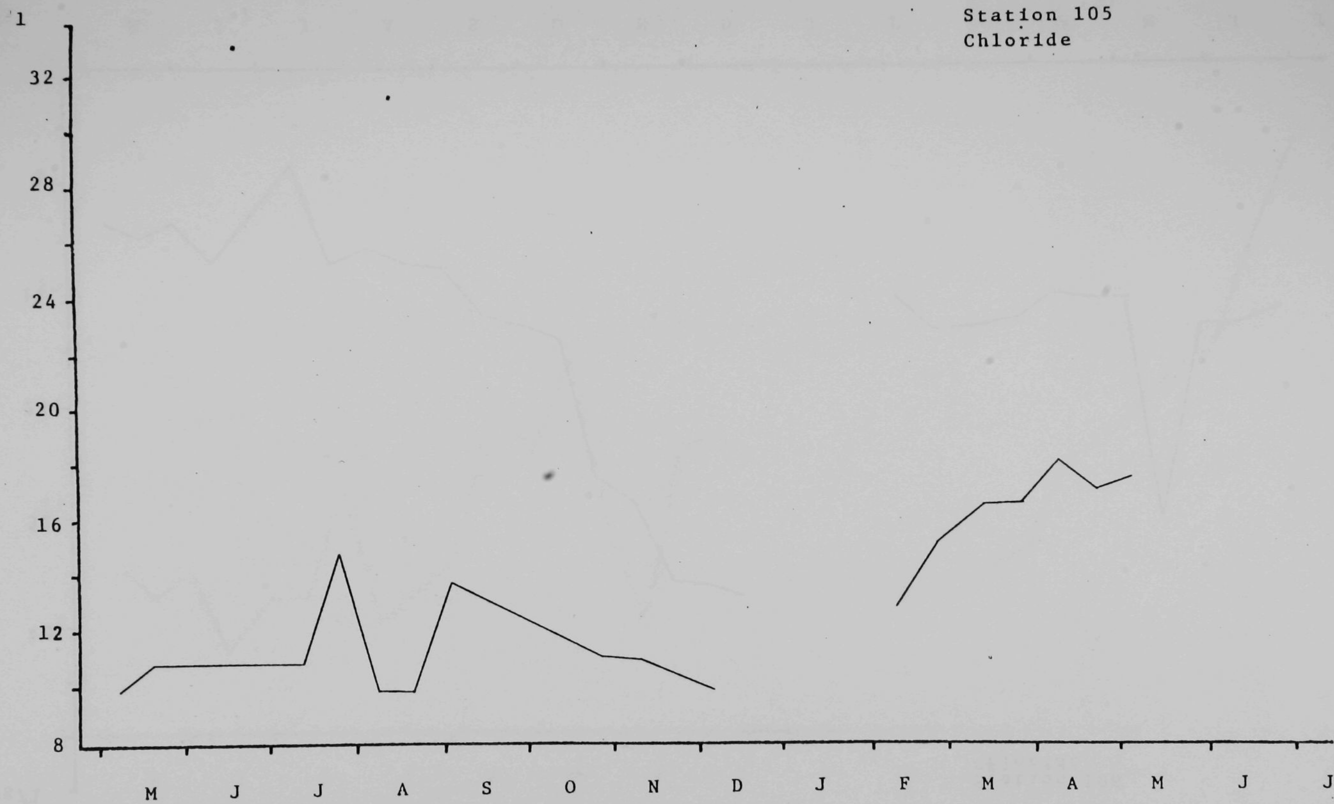

g/l
28
24
20
16
12
8
4
Station 101
Chloride
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

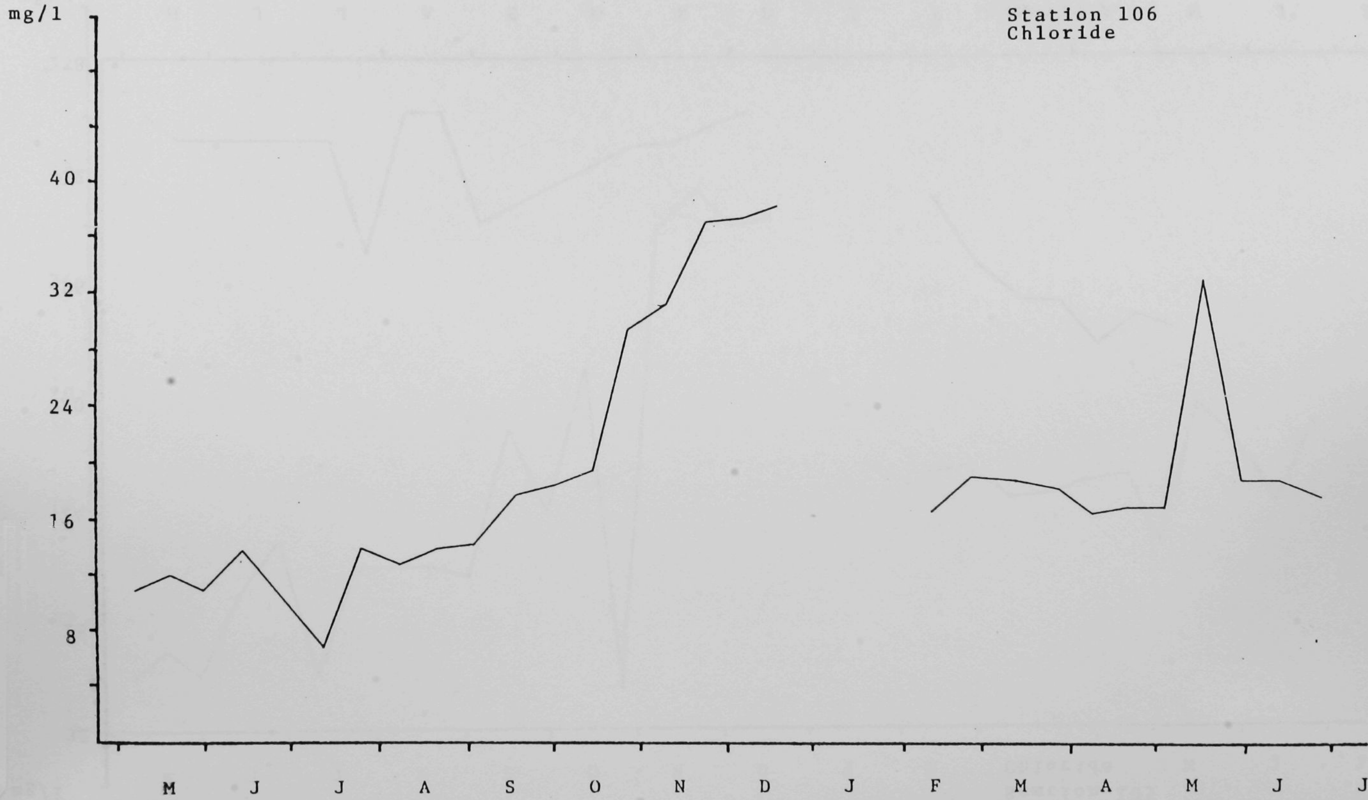

mg/l
28
24
20
16
12
Station 102
Chloride
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



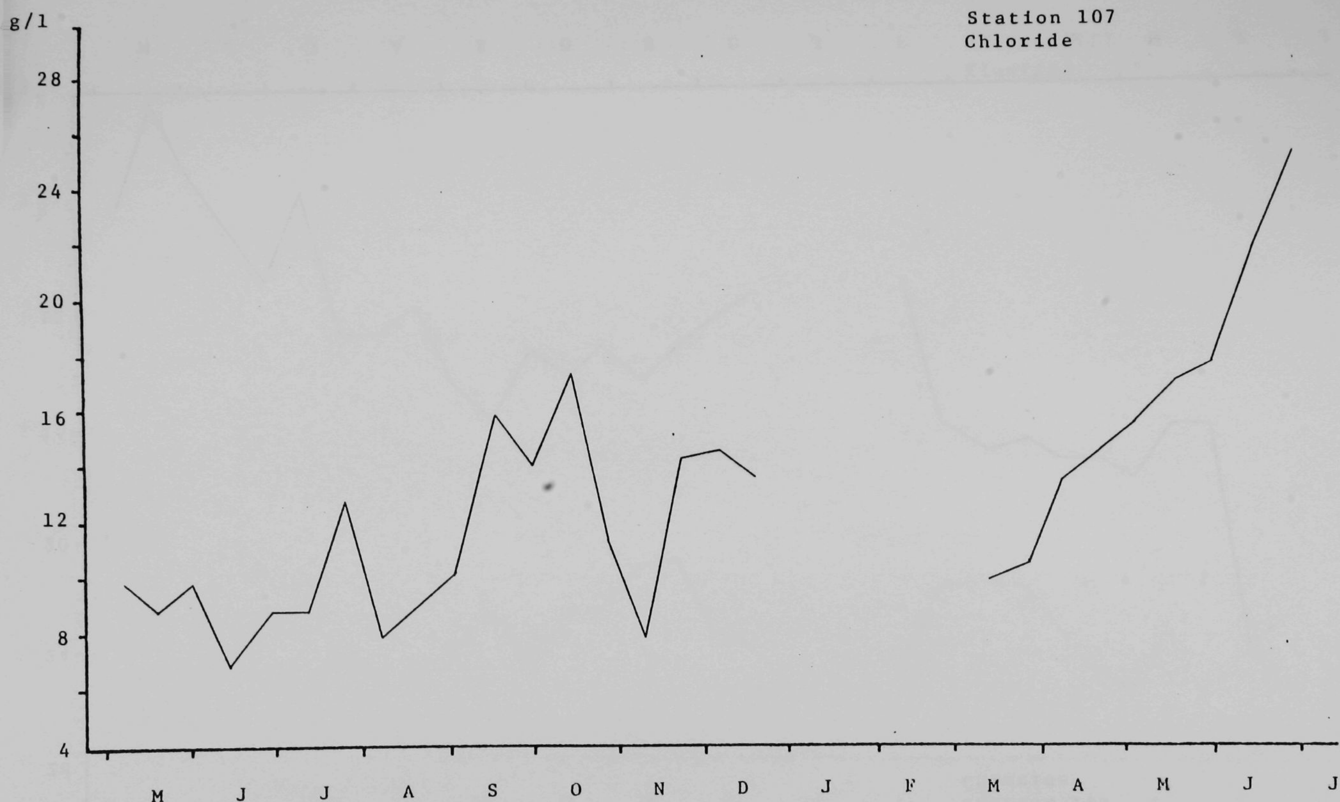
123

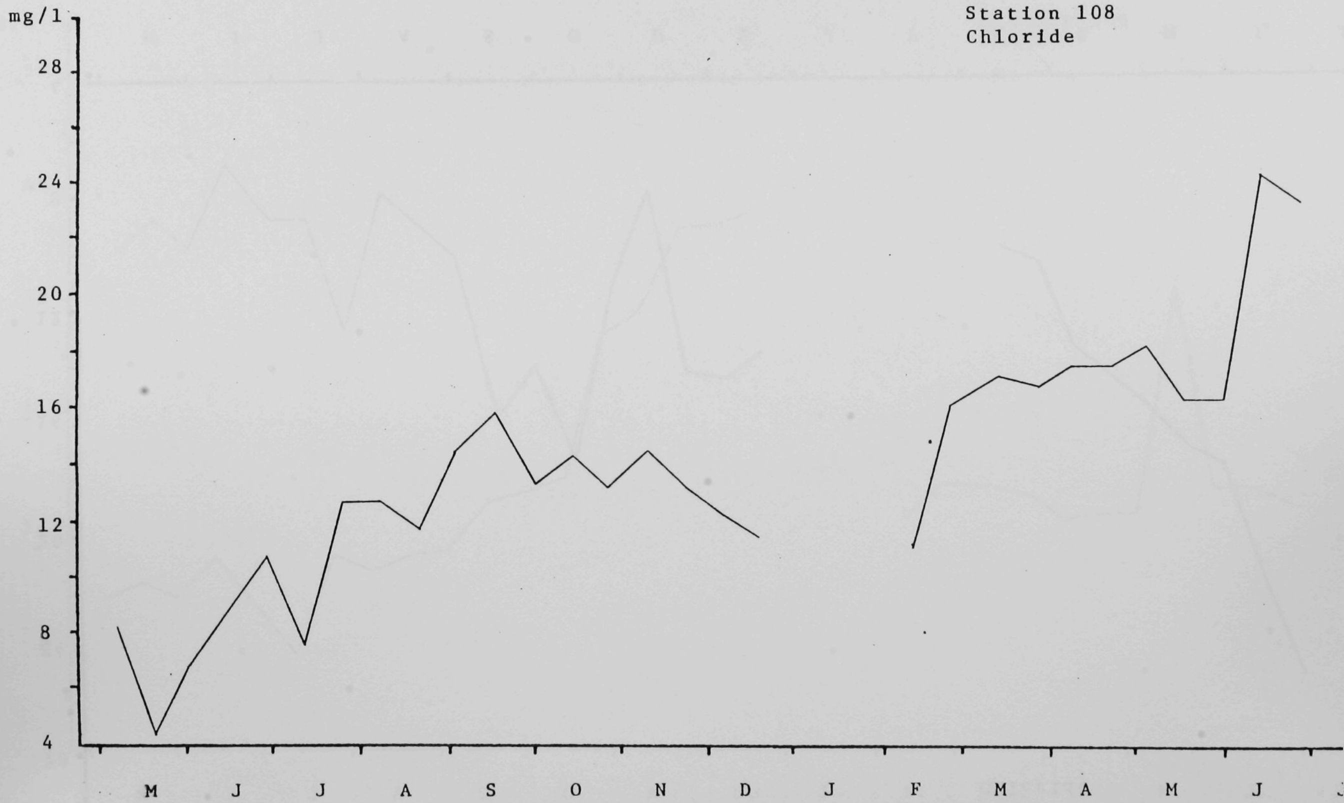

Station 104
Chloride
mg/l
32
28
24
20
16
2
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 105
Chloride
1
32
28
24
20
16
12
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

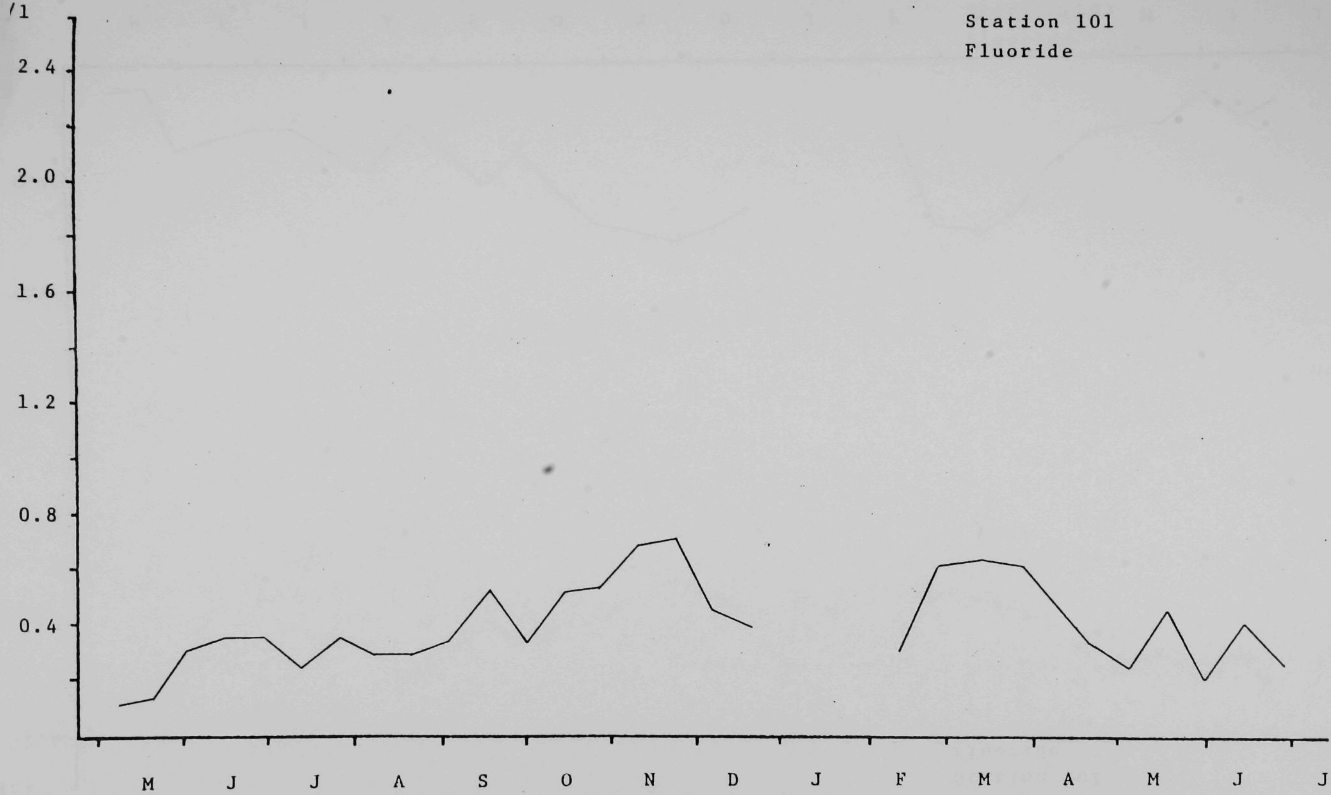


mg/l
Station 106
Chloride
40
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

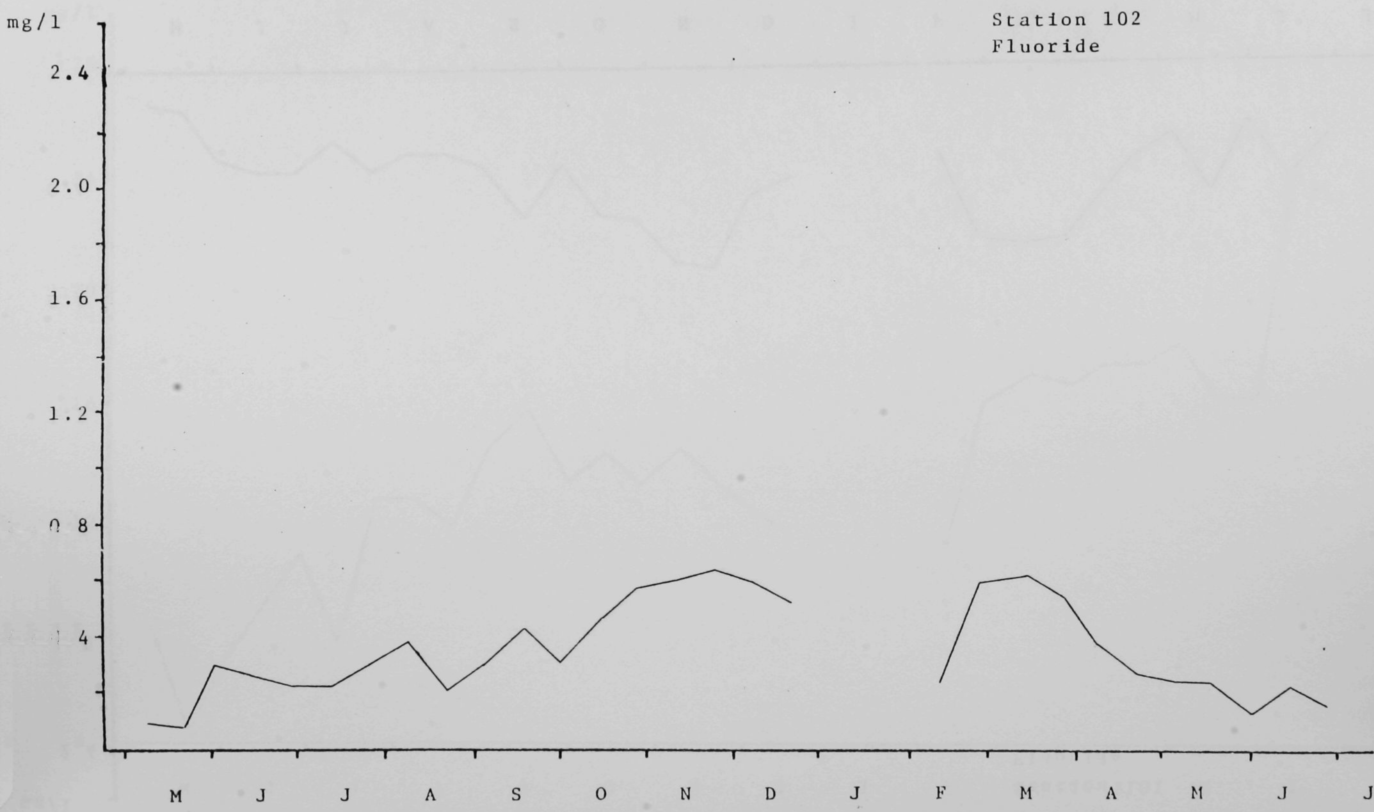

Station 107
Chloride
g/l
28
24
20
16
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

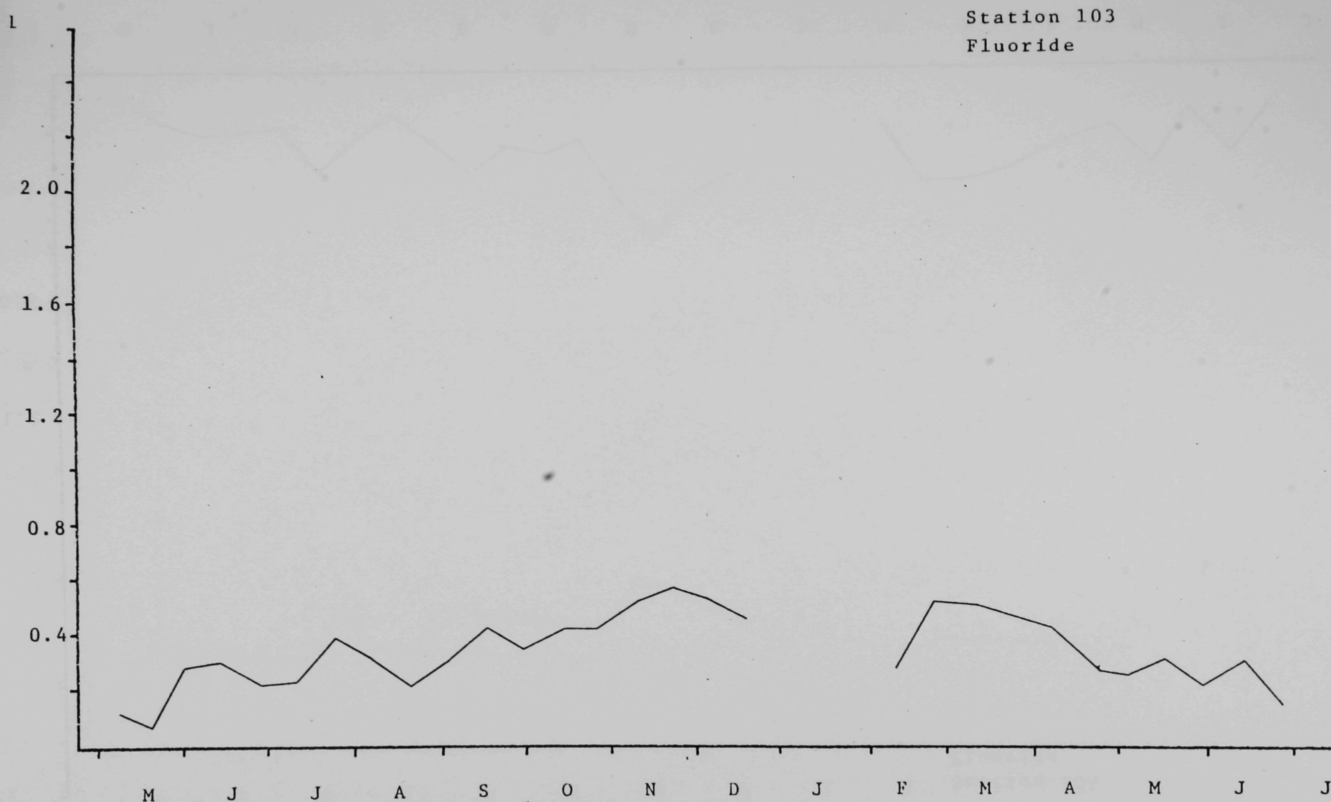


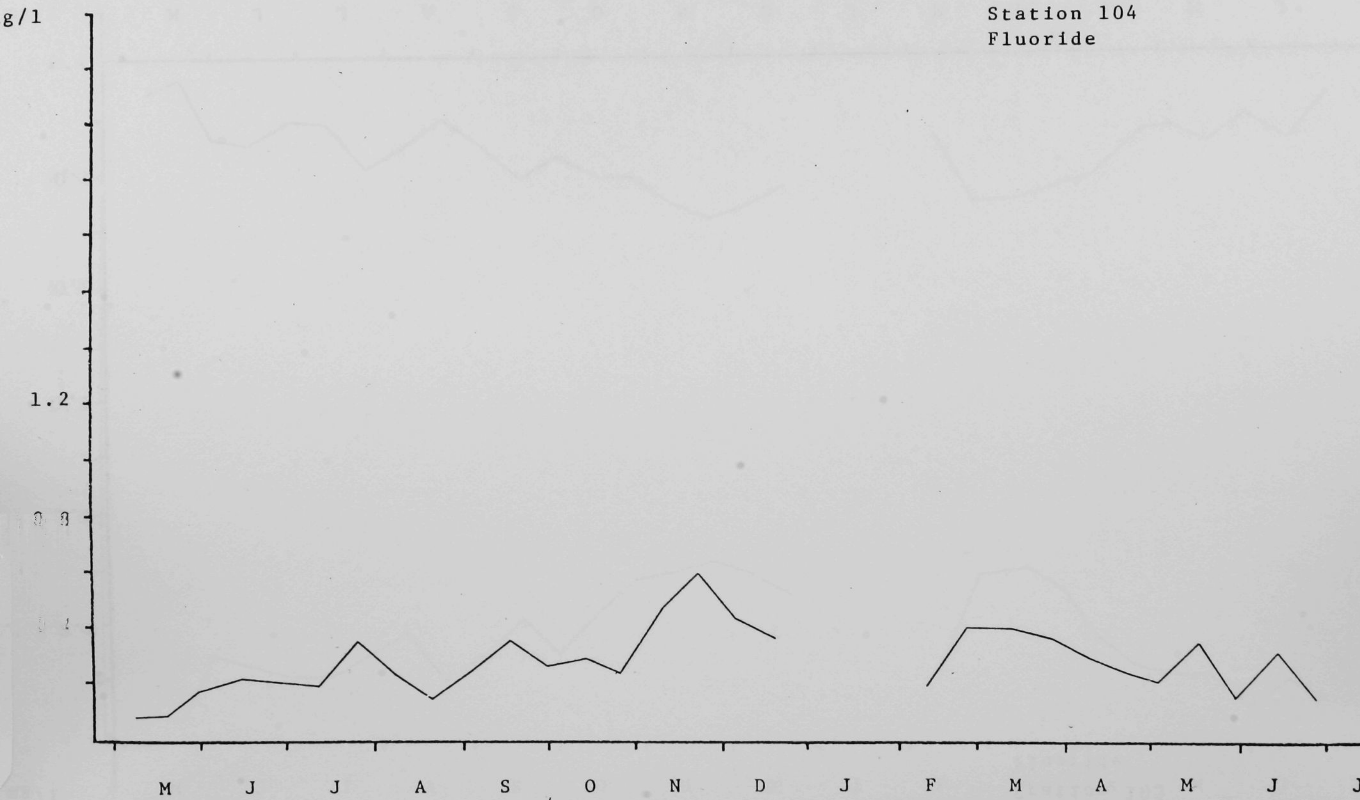
128



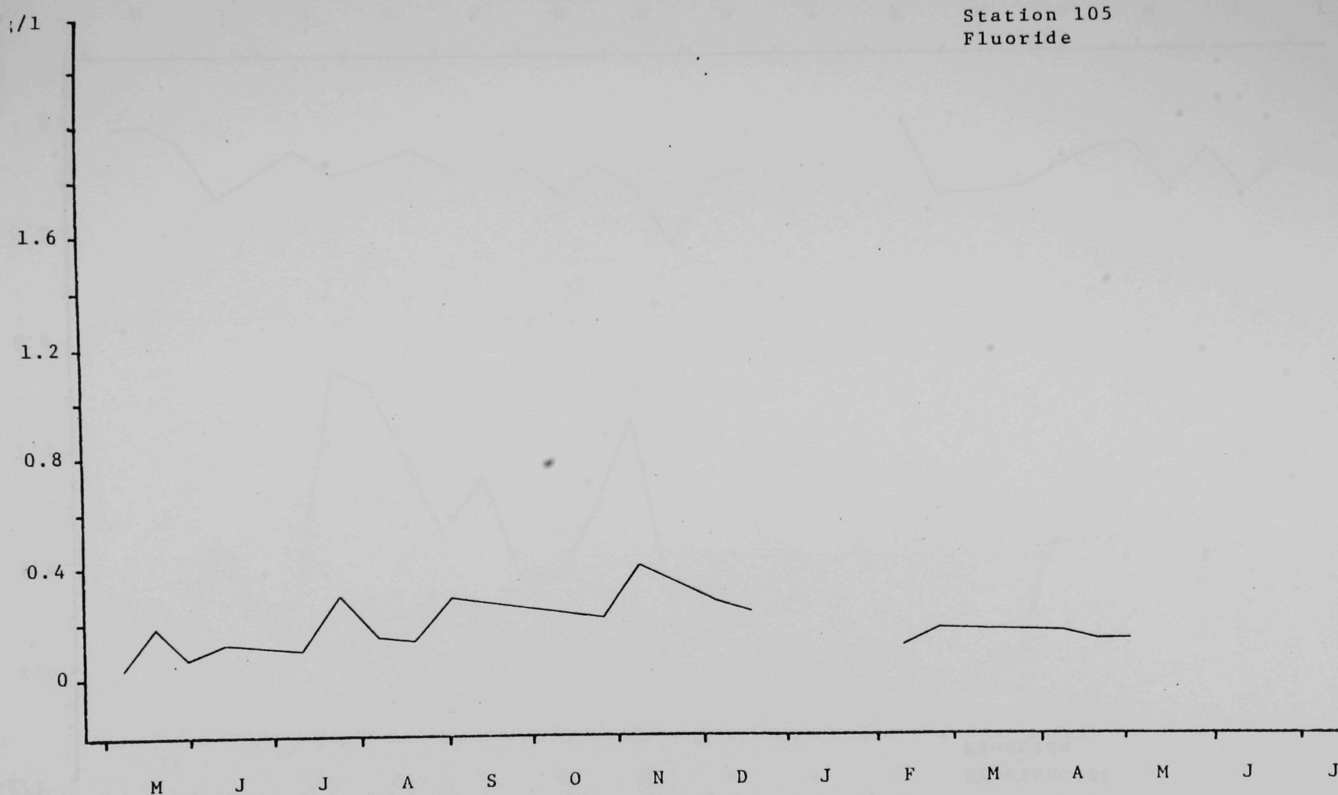
129


mg/l
Station 102
Fluoride
2.4
2.0
1.6
1.2
0.8
0.4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

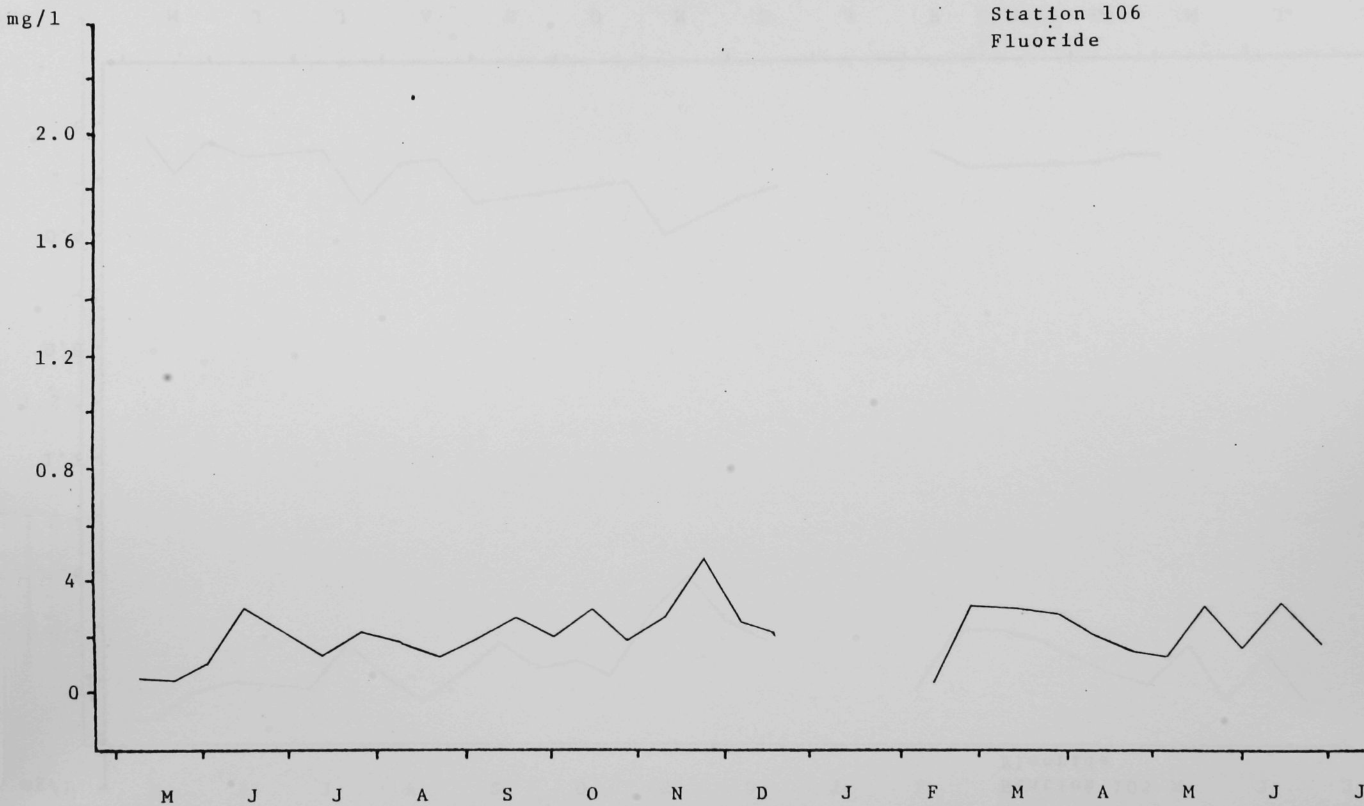

Station 103
Fluoride
2.0
1.6
1.2
0.8
0.4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

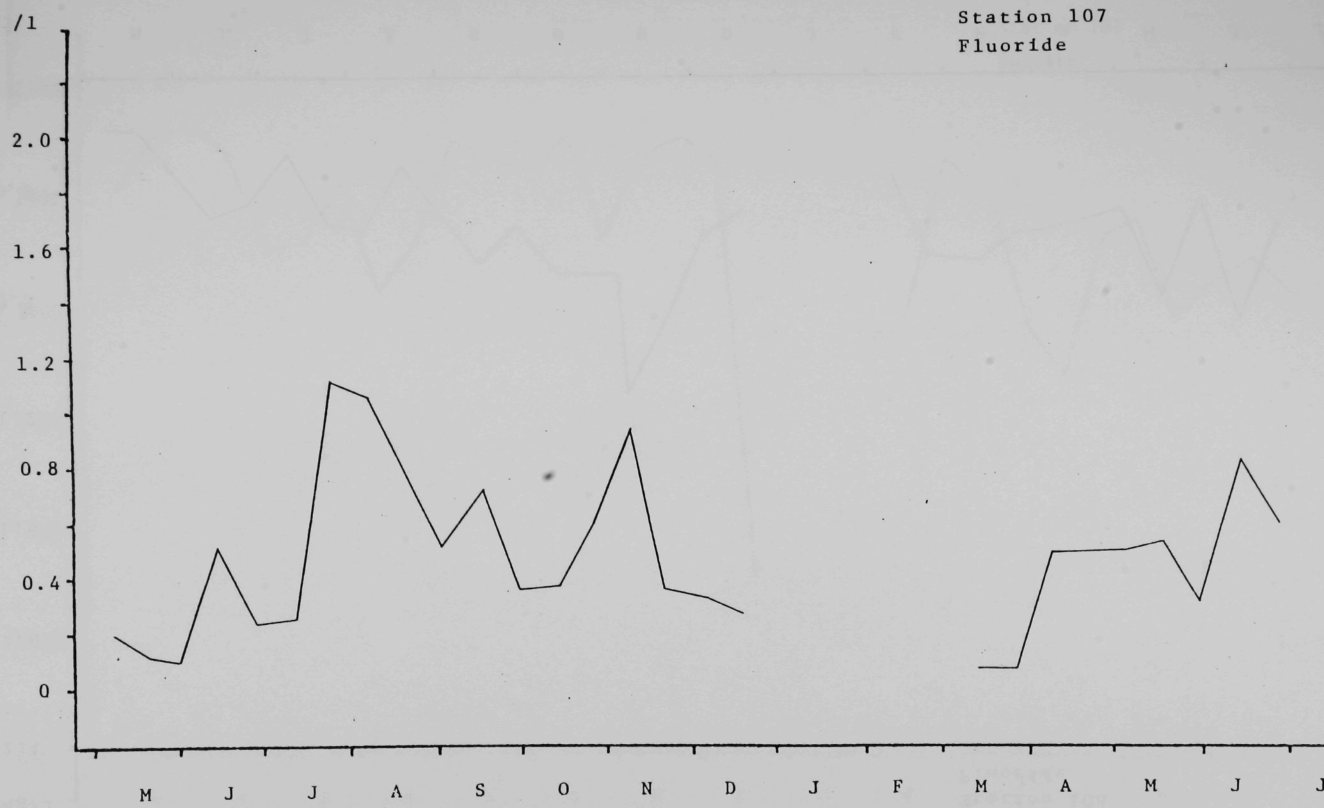


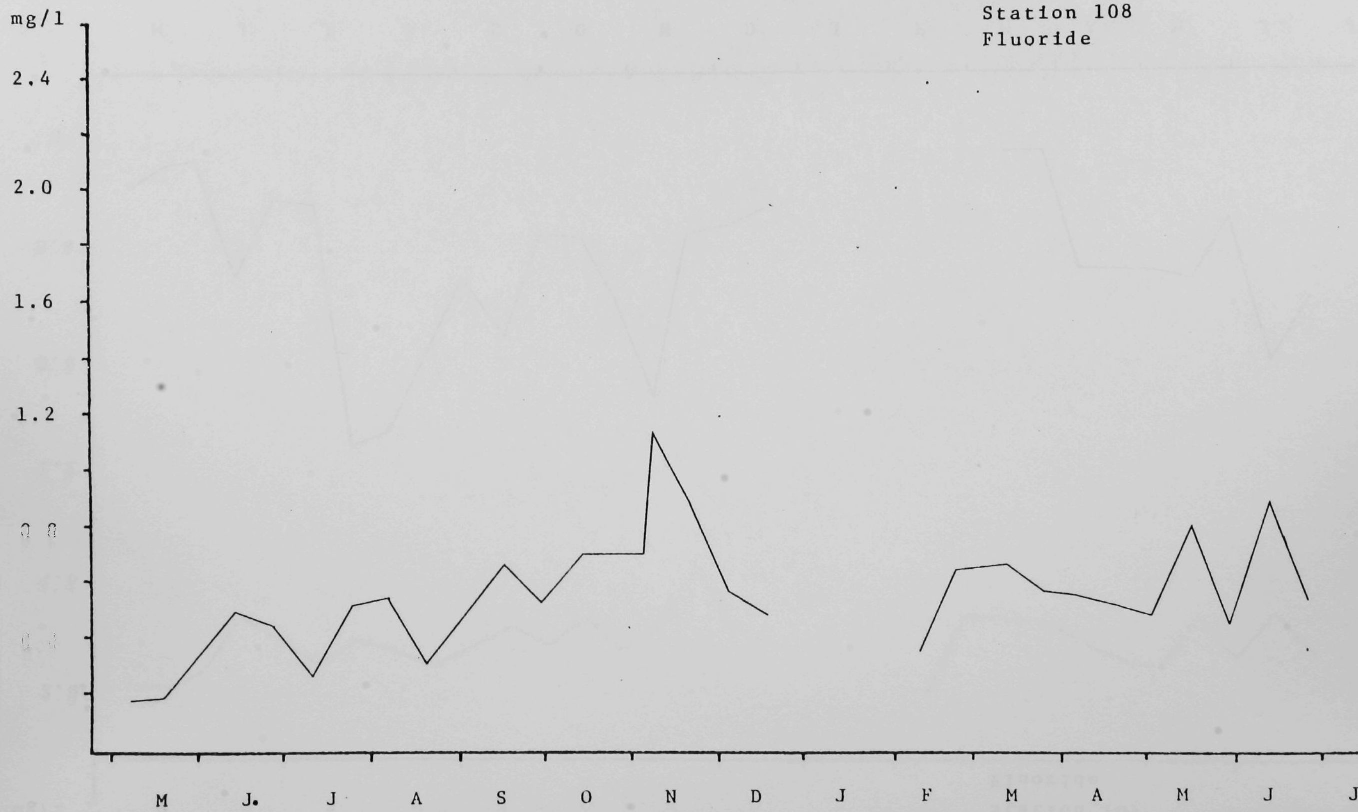
132

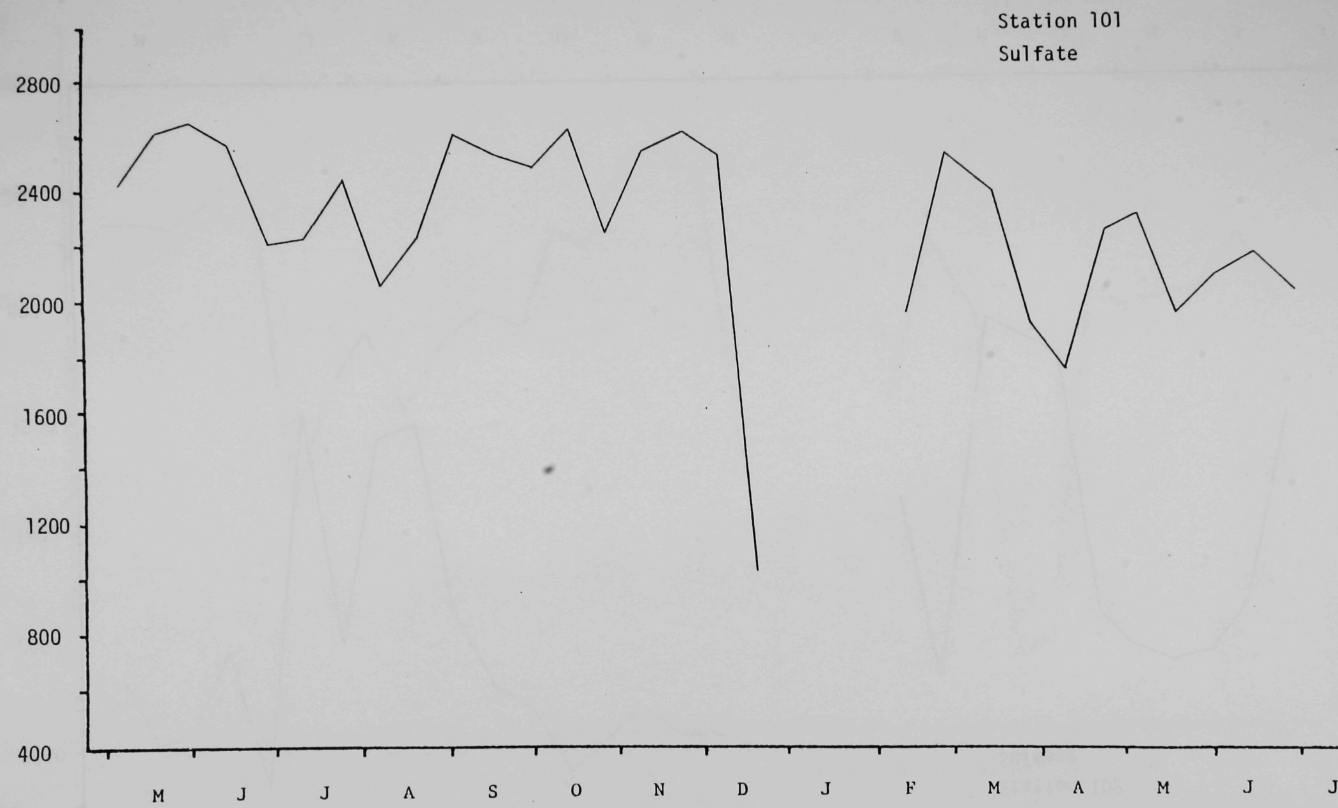


Station 105
Fluoride
;/1
1.6
1.2
0.8
0.4
0
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 106
Fluoride
mg/1
2.0
1.6
1.2
0.8
4
0
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

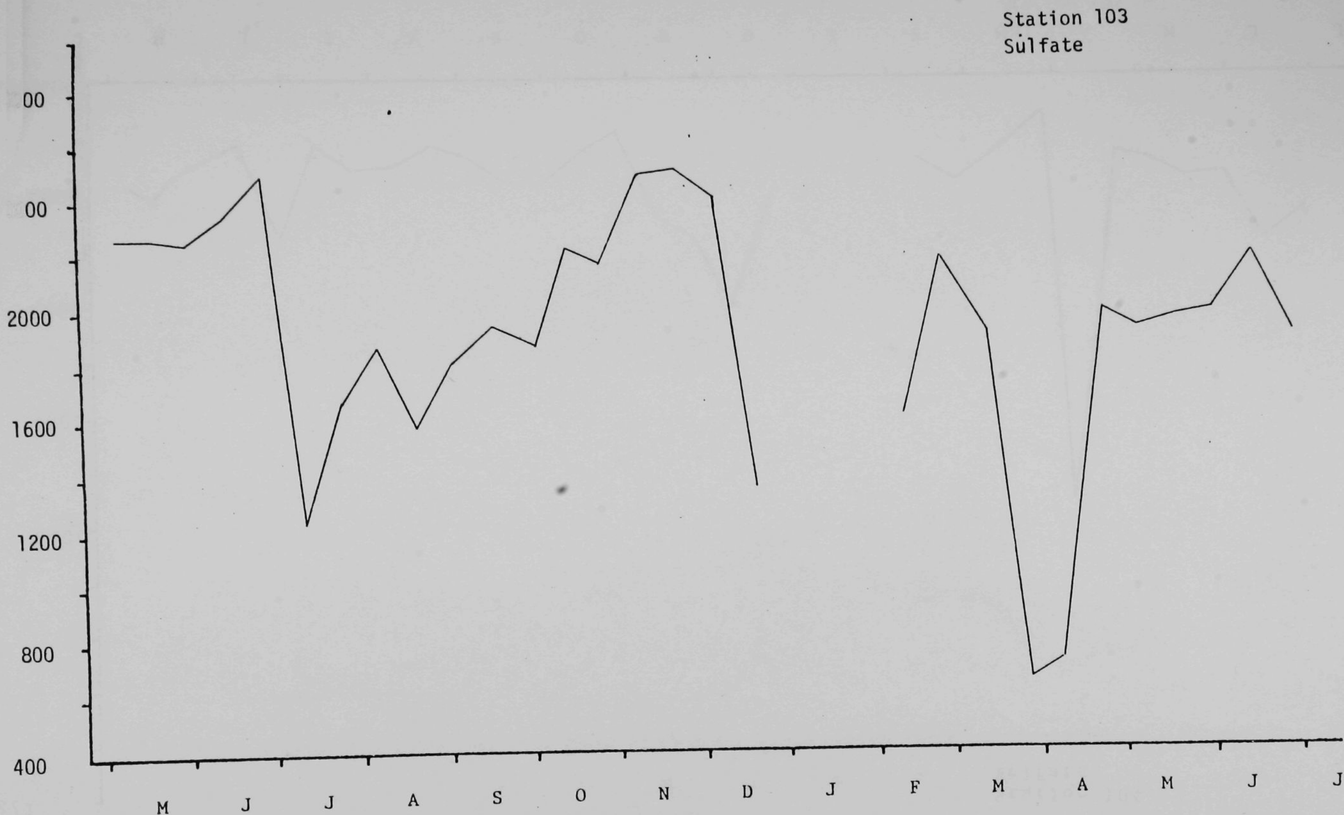

Station 107
Fluoride
/1
2.0
1.6
1.2
0.8
0.4
0
M J J A S O N D J F M A M J J

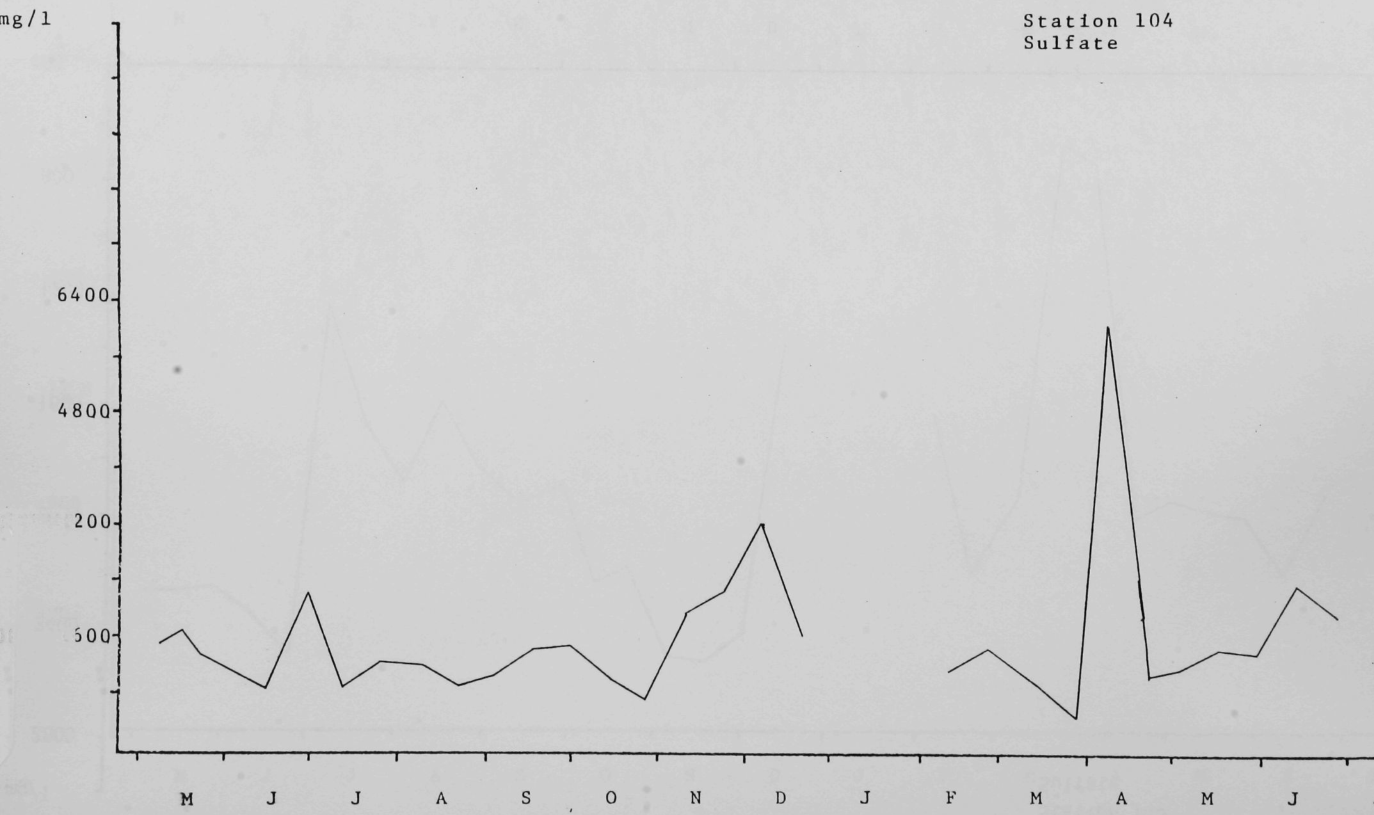

Station 108
Fluoride
mg/l
2.4
2.0
1.6
1.2
M
J.
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 101
Sulfate
2800
2400
2000
1600
1200
800
400
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

137

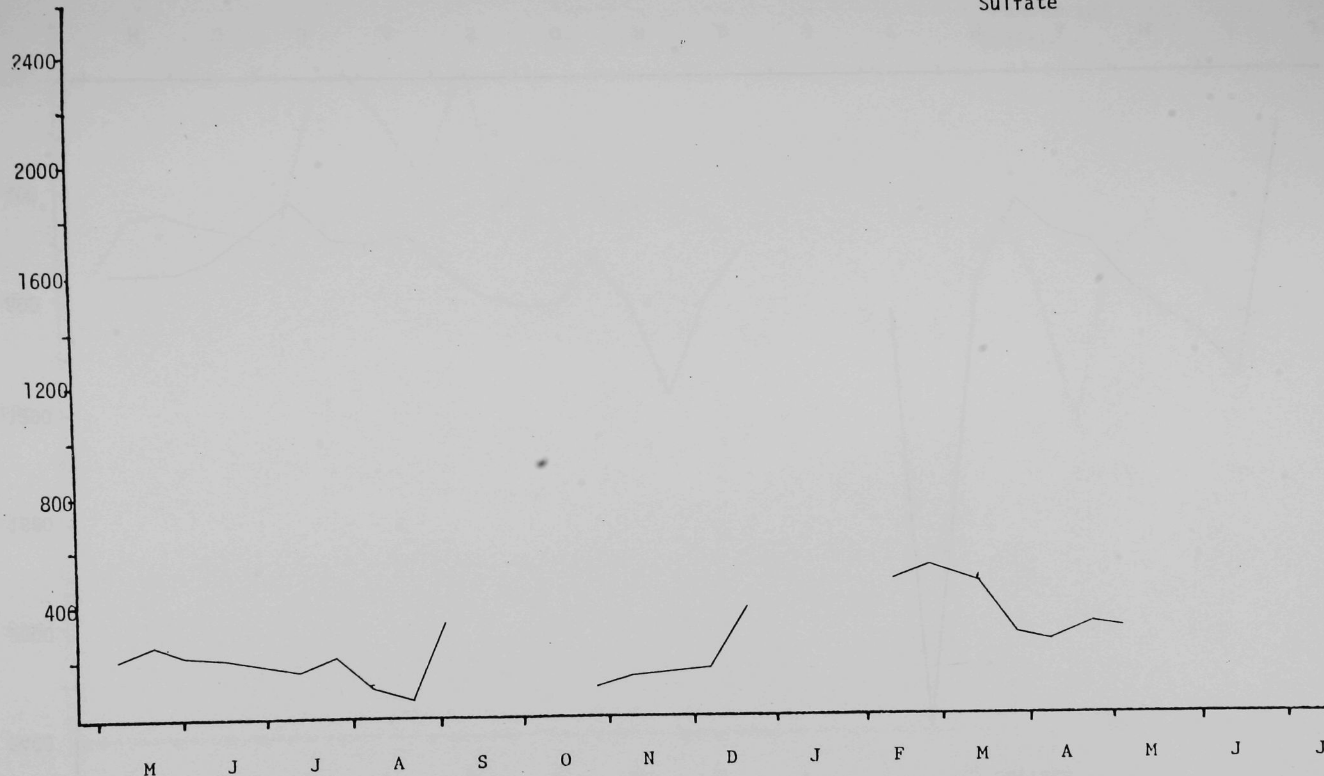

mg/l
Station 102
Sulfate
2400
2000
1600
1200
800
M J J A S O N D J F M A M J J

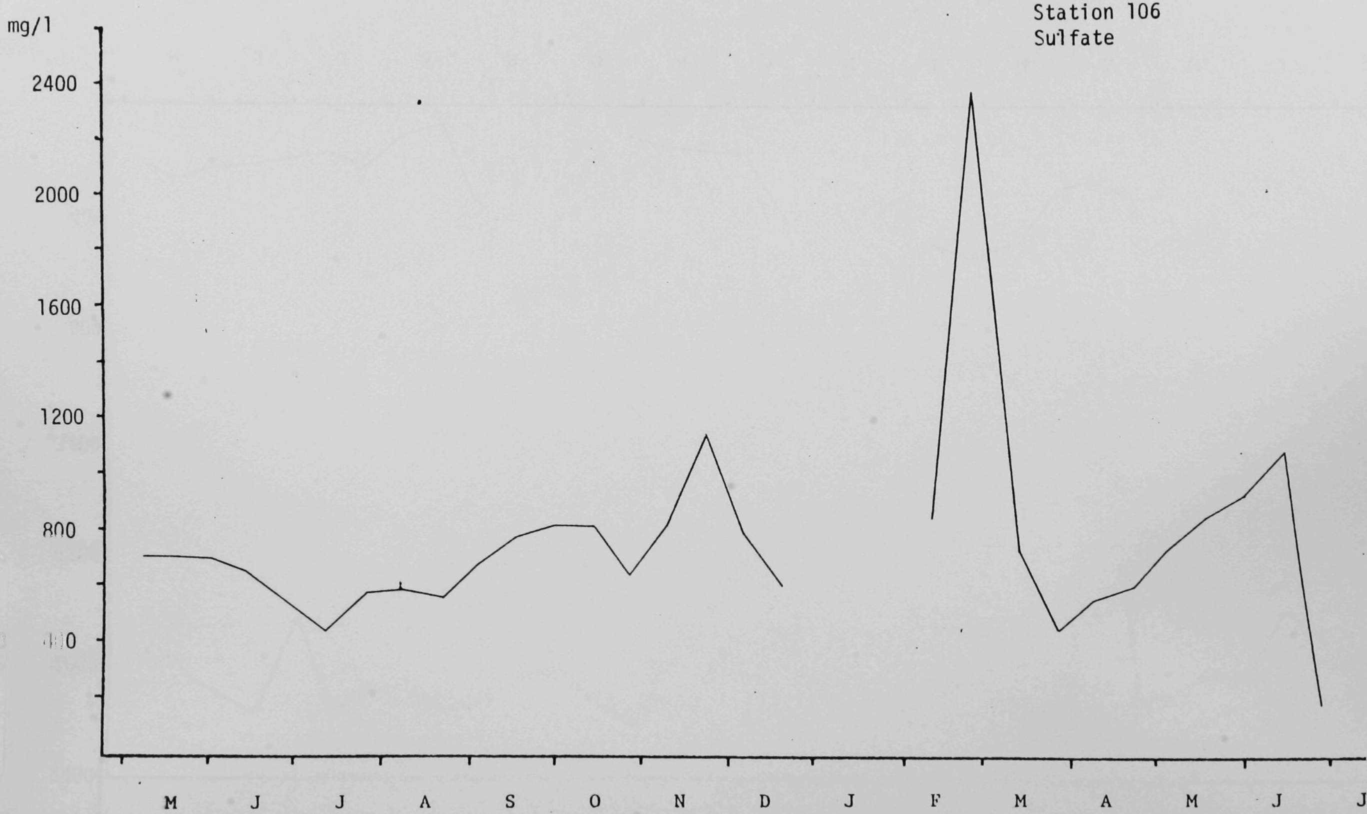

Station 103
Sulfate
00
00
2000
1600
1200
800
400
M J J A S O N D J F M A M J J

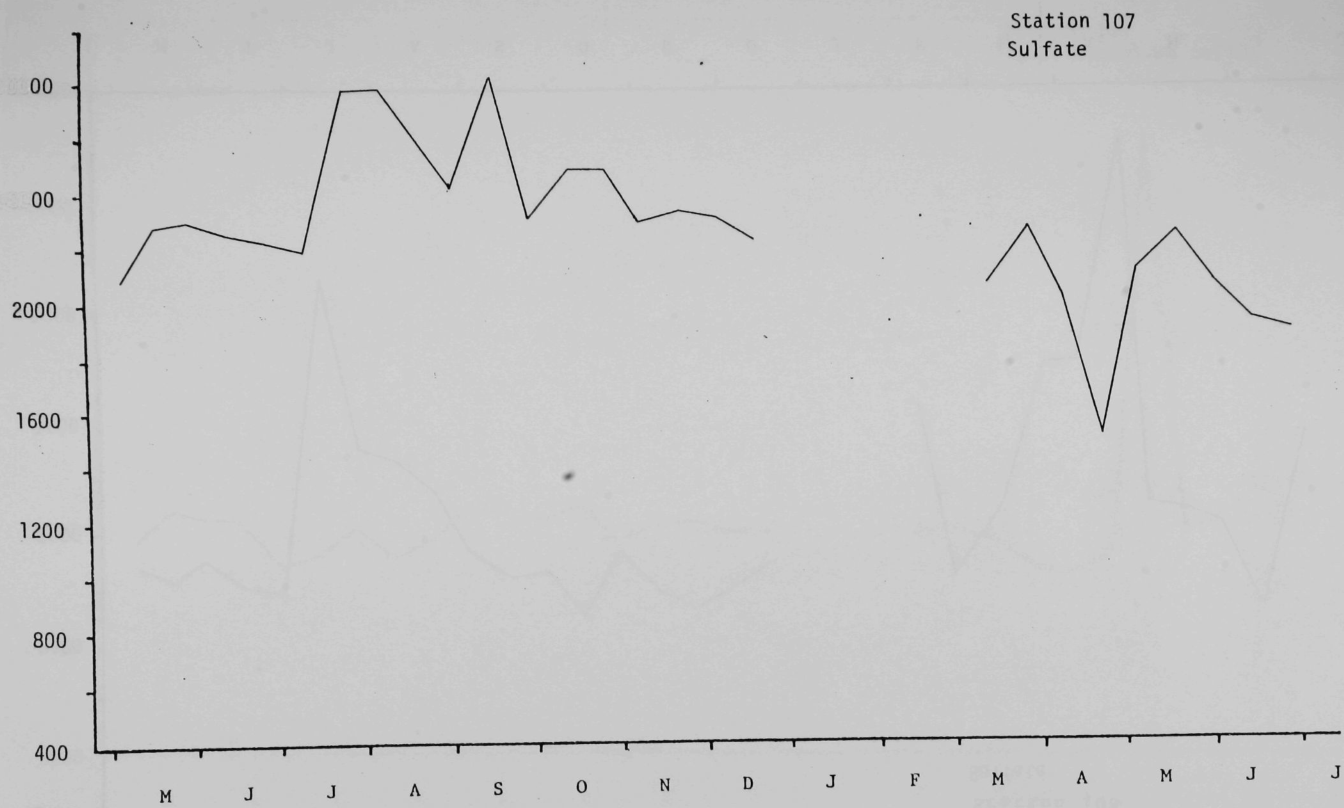


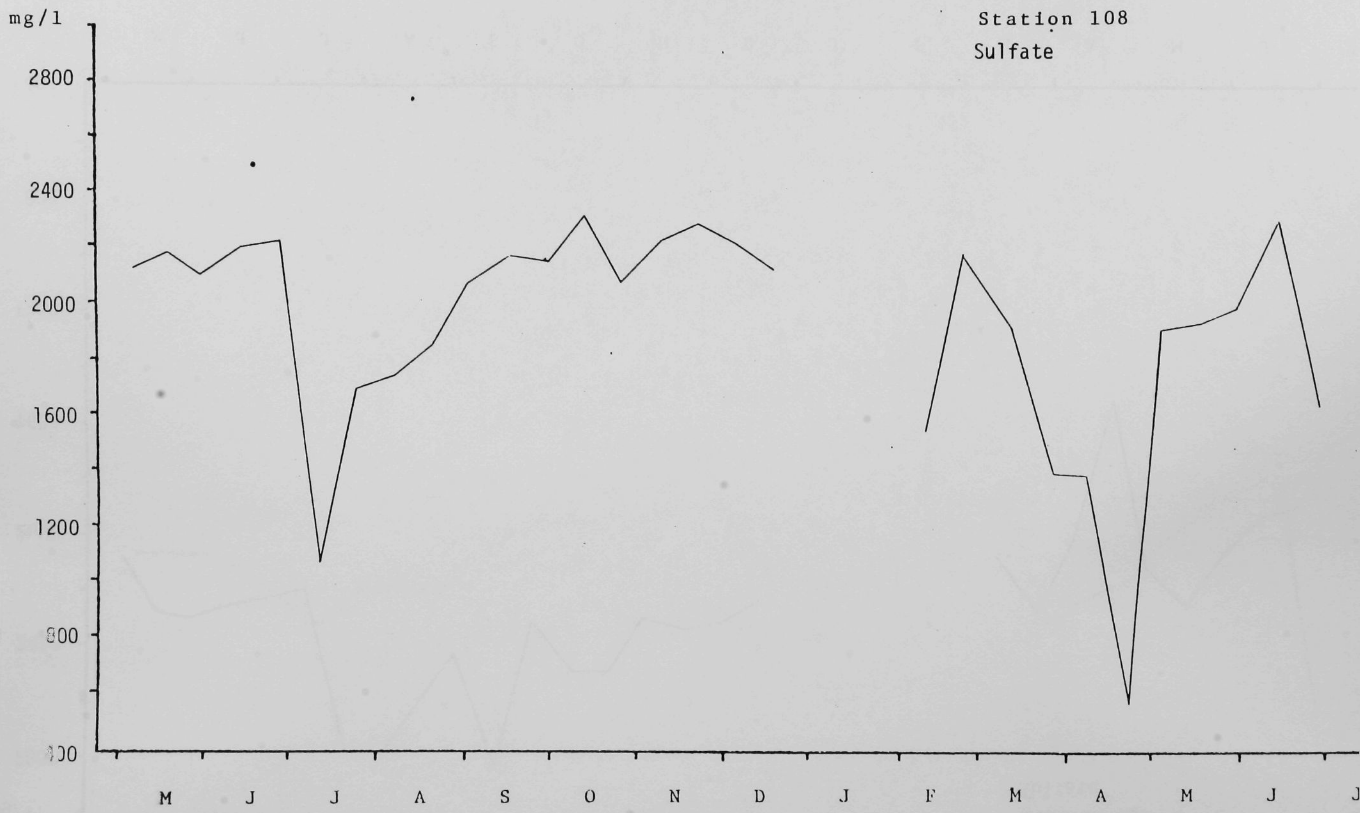
mg/l
Station 104
Sulfate
6400
4800
200
600
M
J
J
A
S
O
N
D
J
F
M
A
M
J

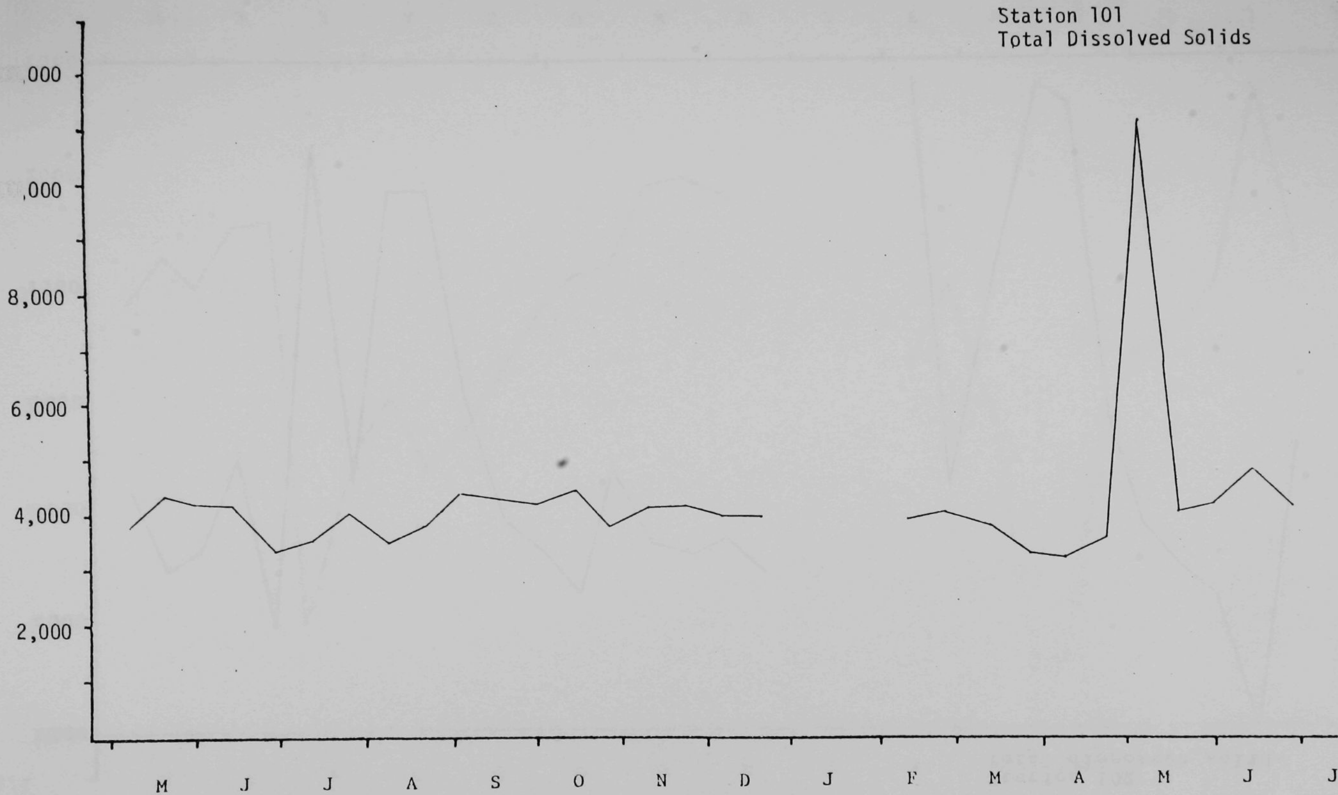
Station 105
Sulfate

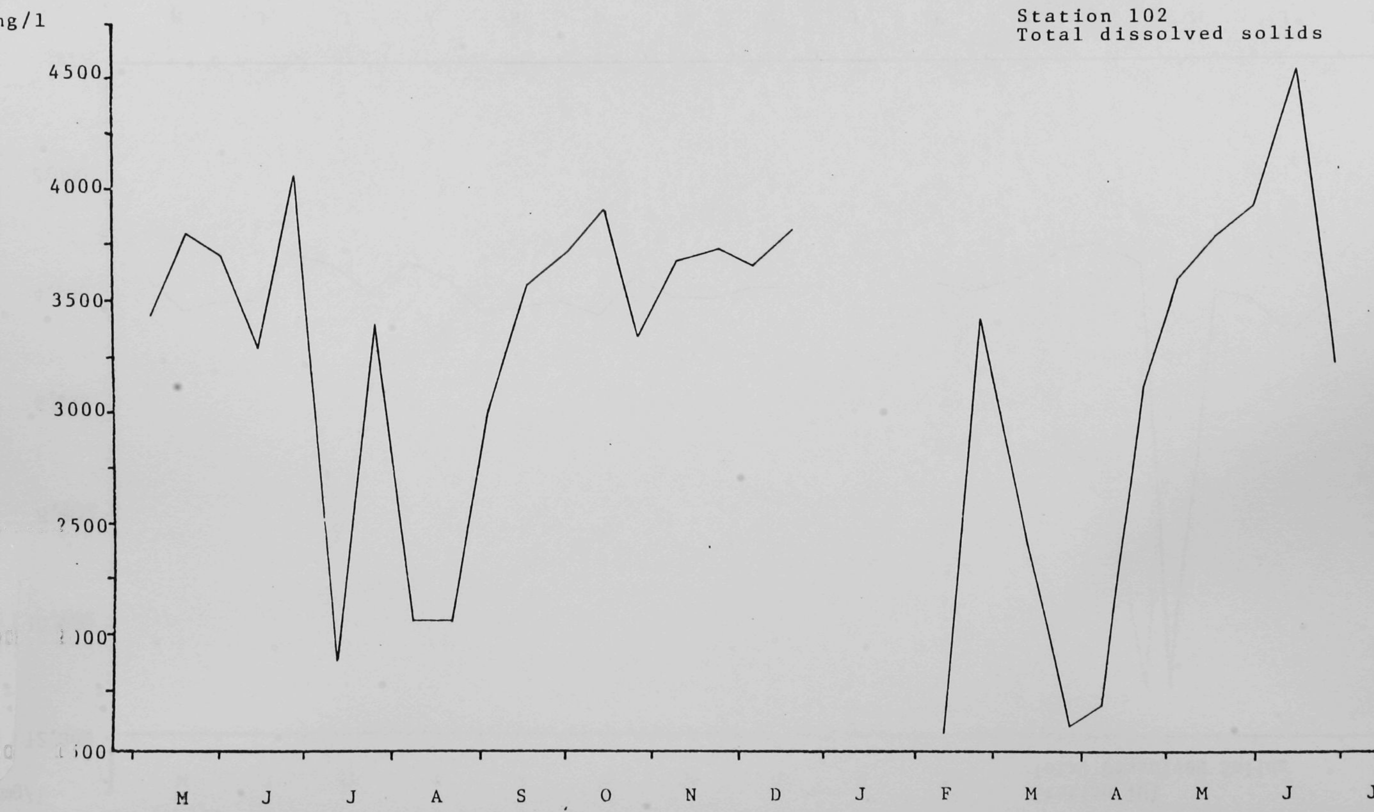


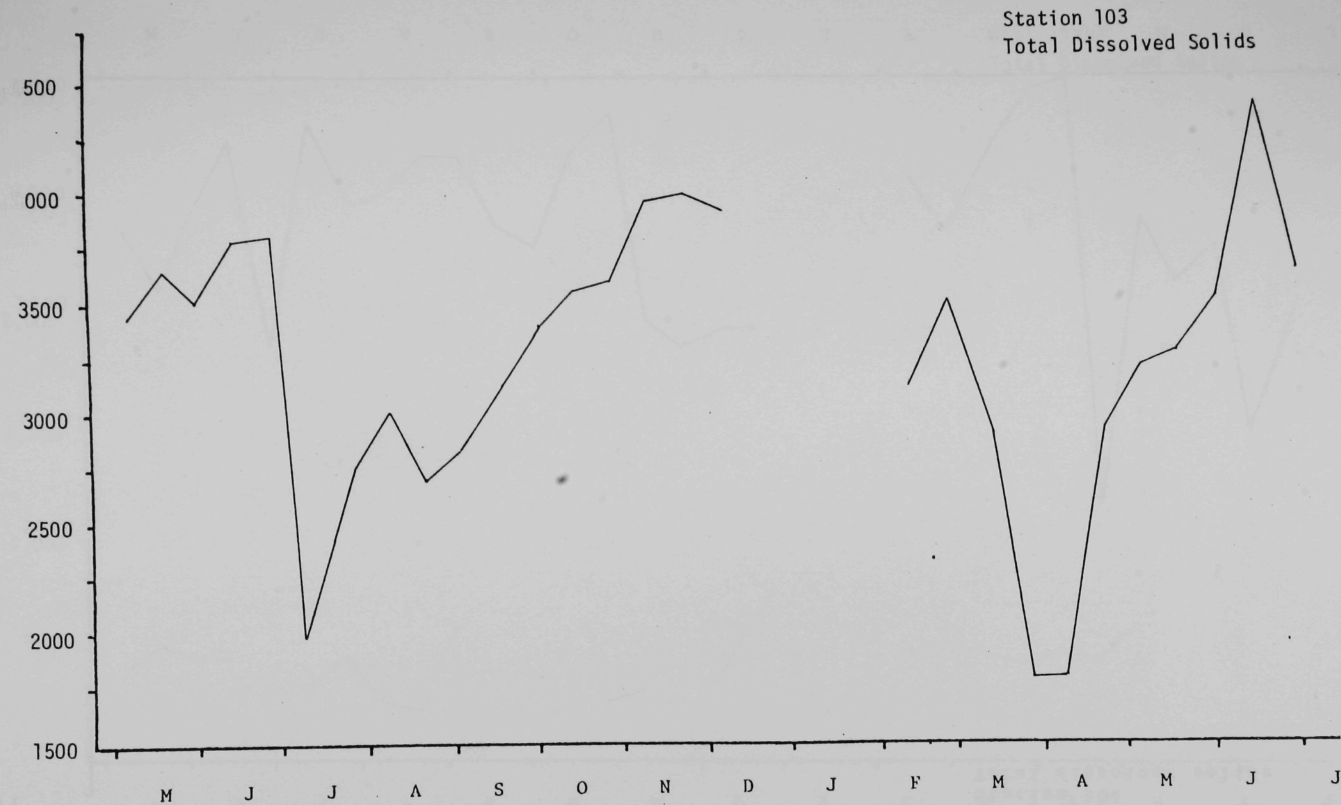

Station 106
Sulfate
mg/l
2400
2000
1600
1200
800
400
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

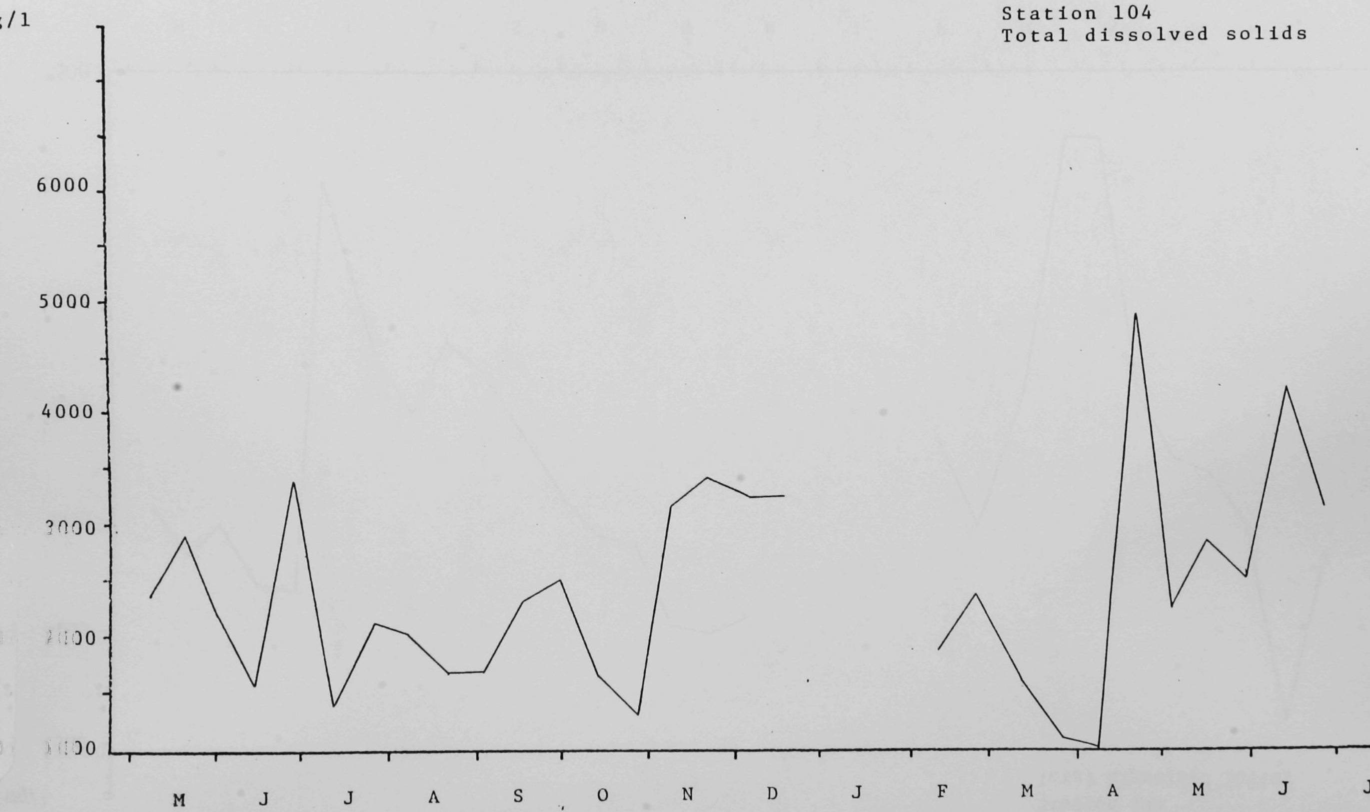

Station 107
Sulfate
00
00
2000
1600
1200
800
400
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 108
Sulfate
mg/l
2800
2400
2000
1600
1200
800
400
M J J A S O N D J F M A M J J

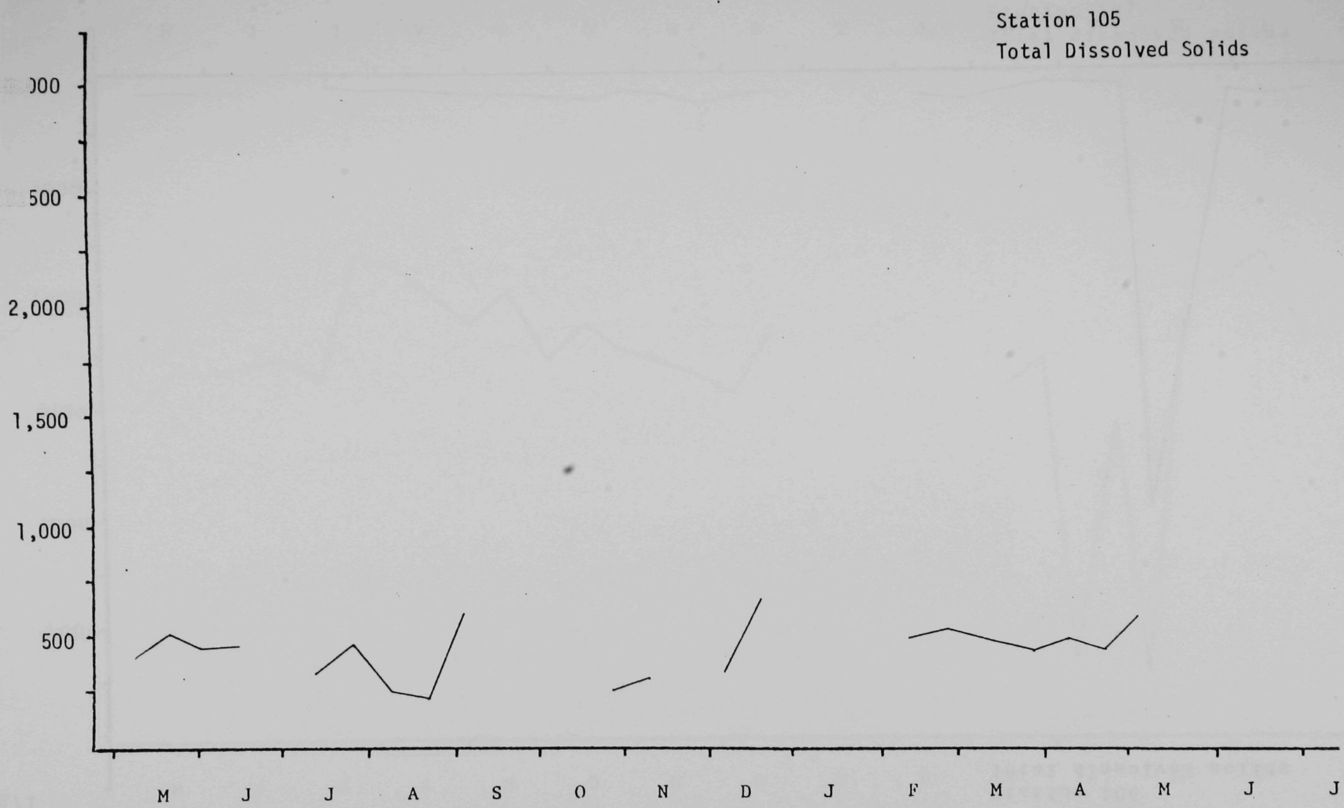

Station 101
Total Dissolved Solids
,000
,000
8,000
6,000
4,000
2,000
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

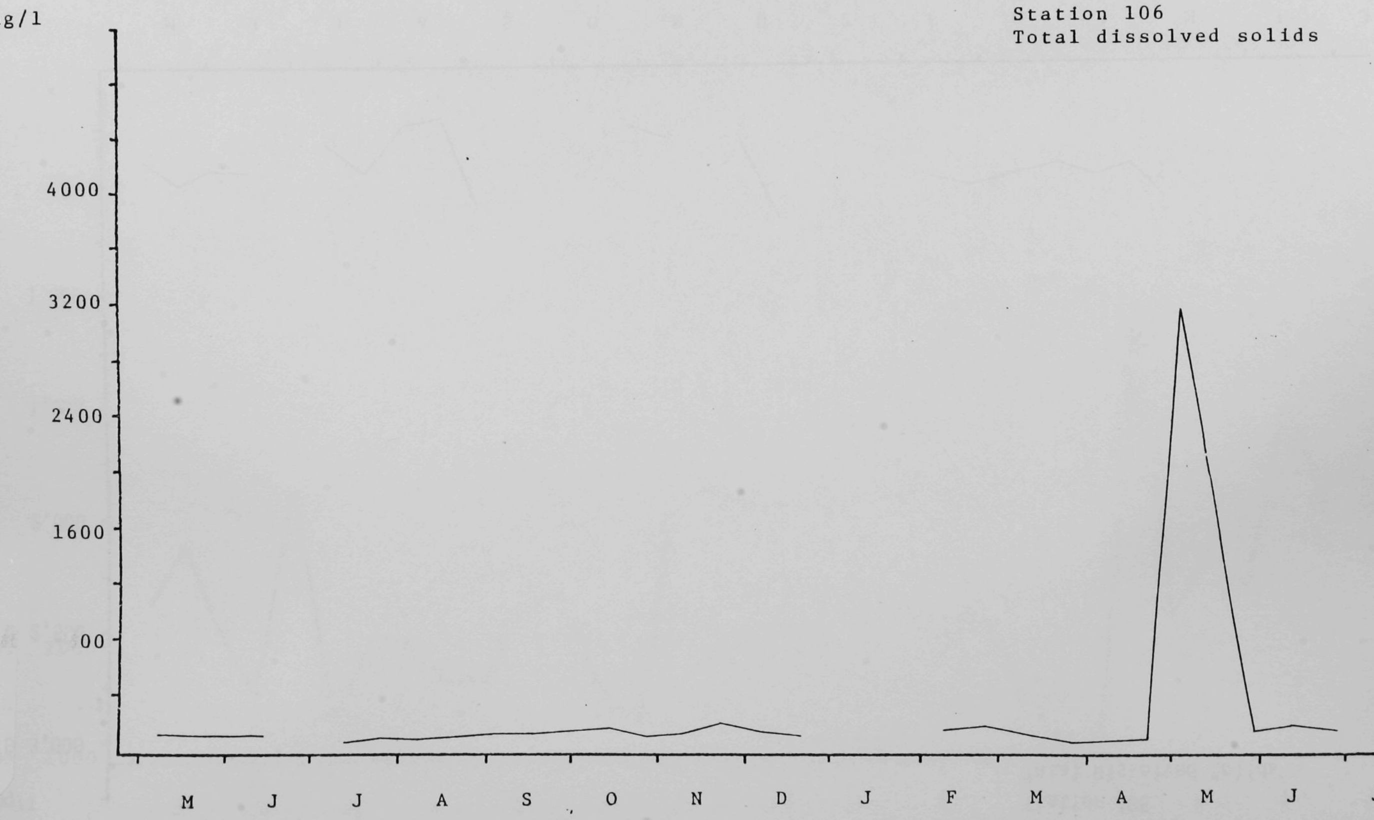

Station 102
Total dissolved solids
g/l
4500
4000
3500
3000
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

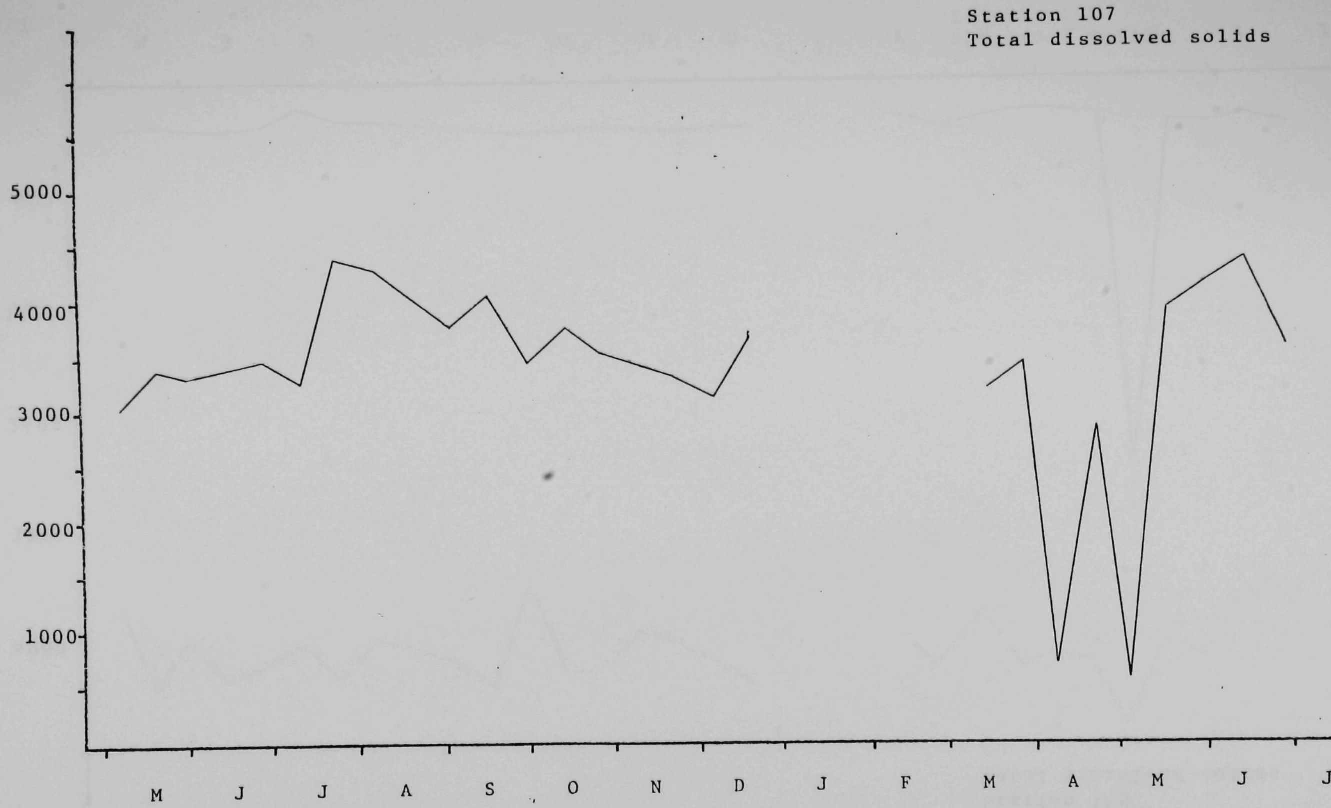

Station 103
Total Dissolved Solids
500
000
3500
3000
2500
2000
1500
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

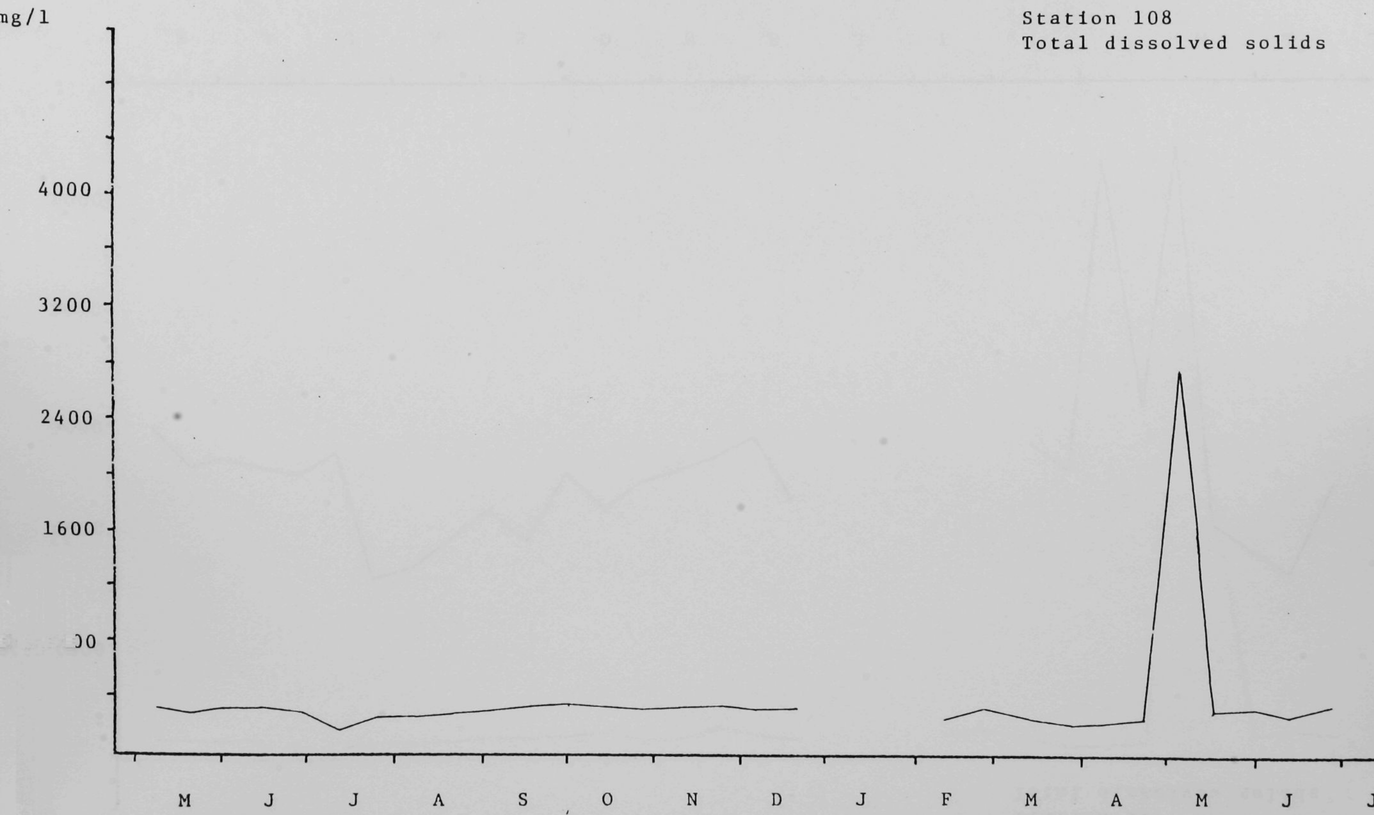

/1
Station 104
Total dissolved solids
6000
5000
4000
3000
2000
1000
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

148


Station 105
Total Dissolved Solids
2,000
1,500
1,000
500
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

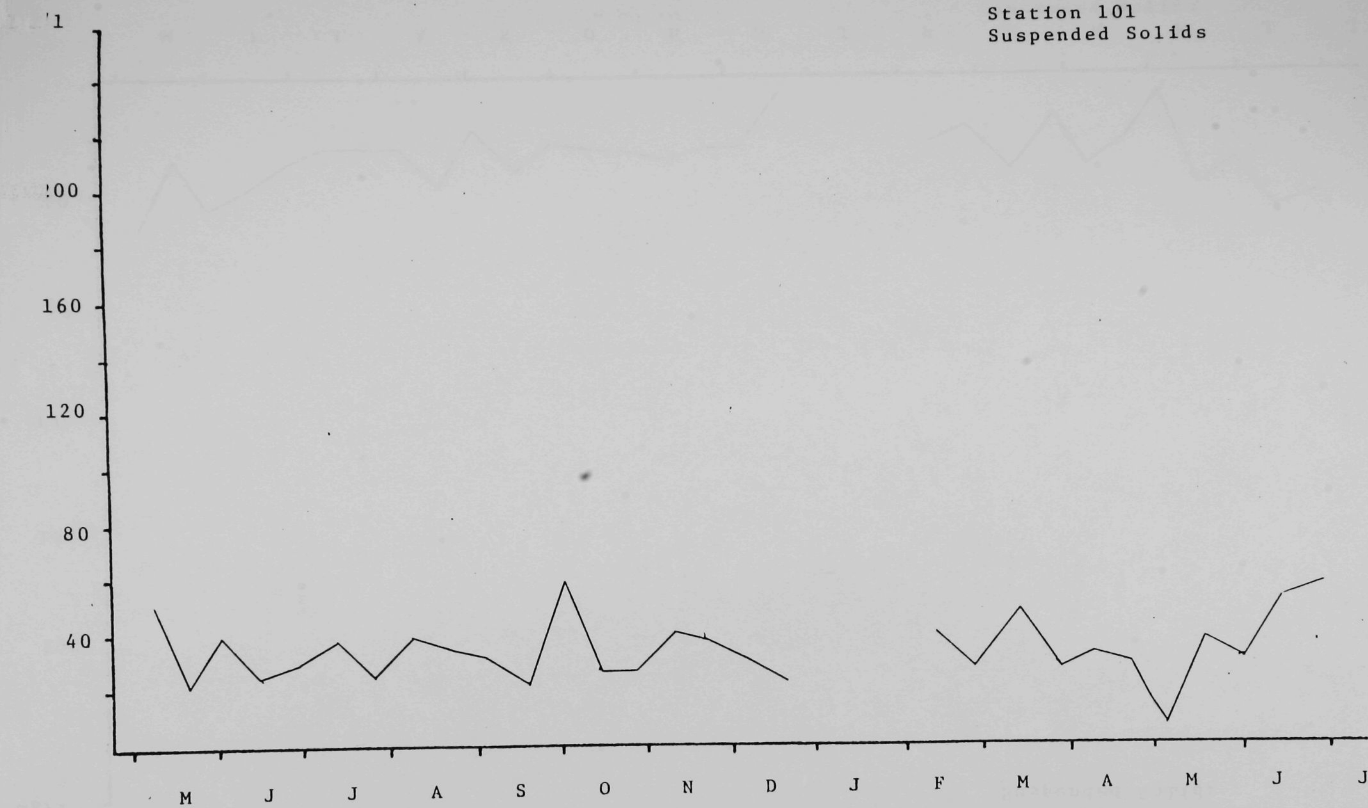

Station 106
Total dissolved solids
g/l
4000
3200
2400
1600
00
M
J
J
A
S
O
N
D
J
F
M
A
M
J

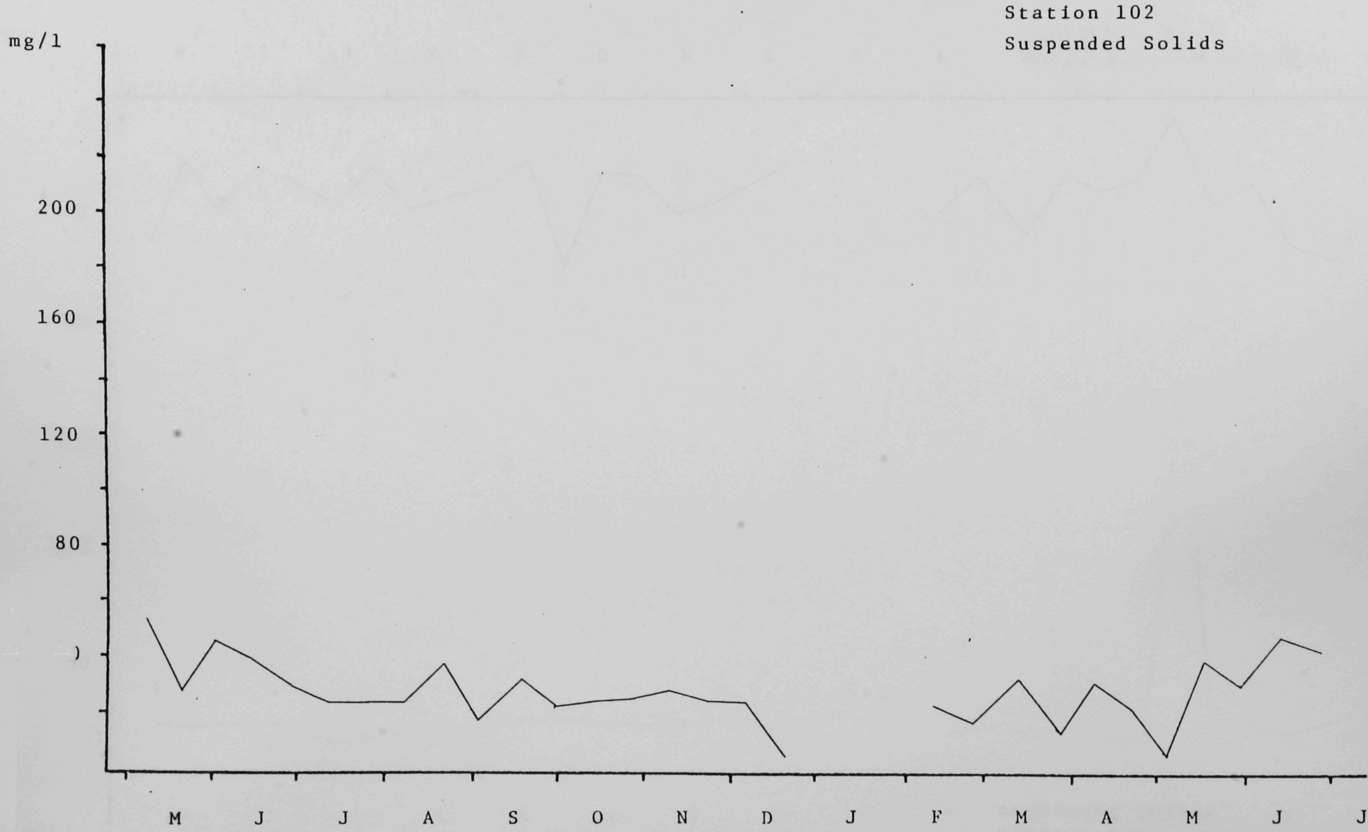

Station 107
Total dissolved solids
5000
4000
3000
2000
1000
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

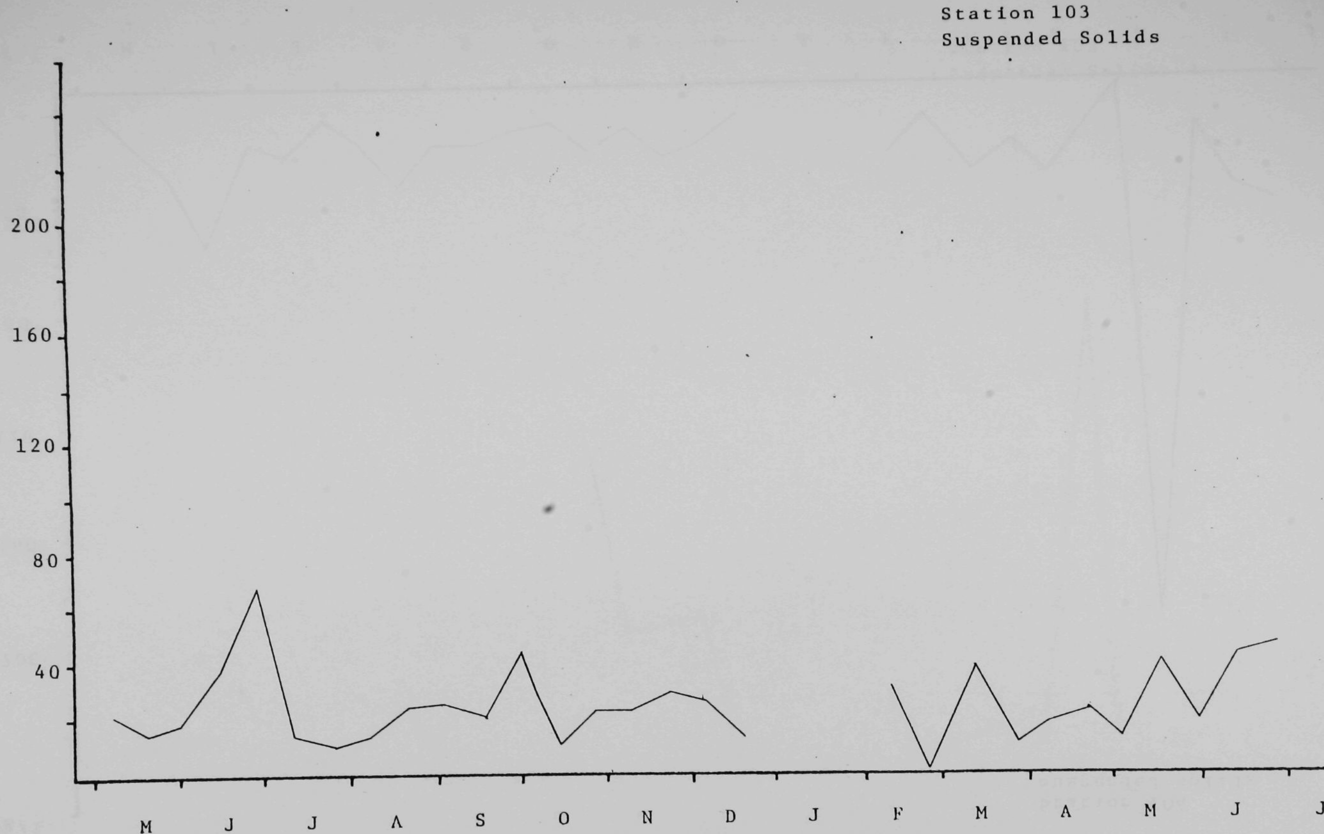


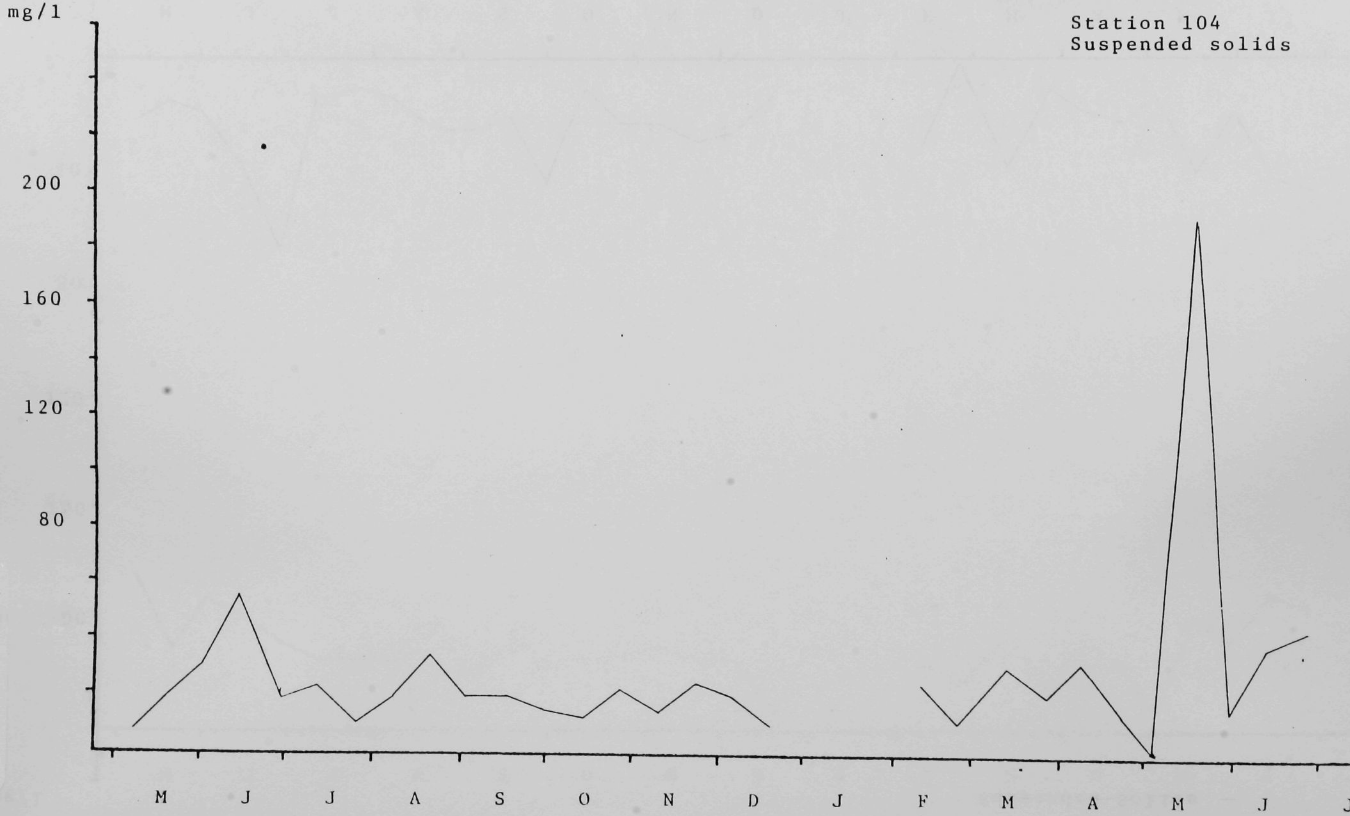
mg/l
Station 108
Total dissolved solids
4000
3200
2400
1600
00
M J J A S O N D J F M A M J J

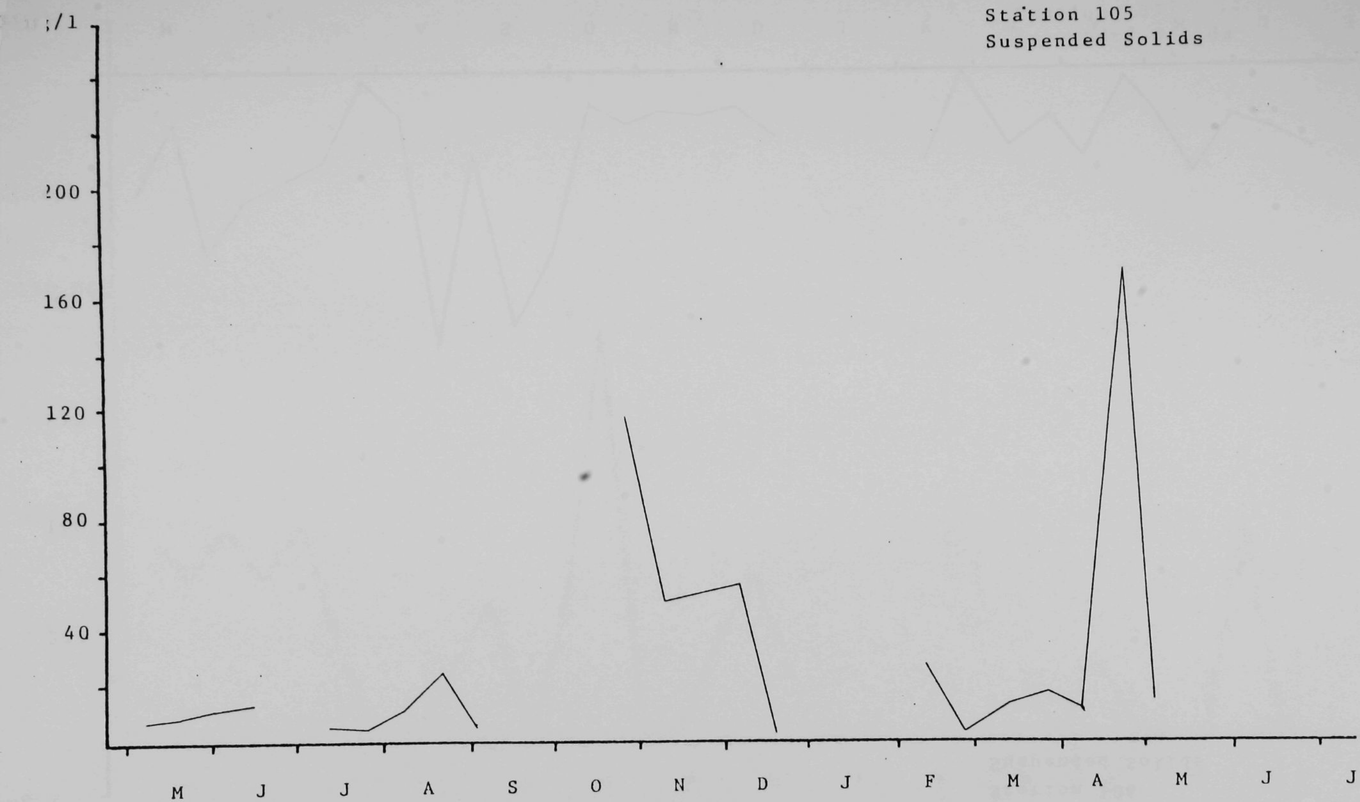
152

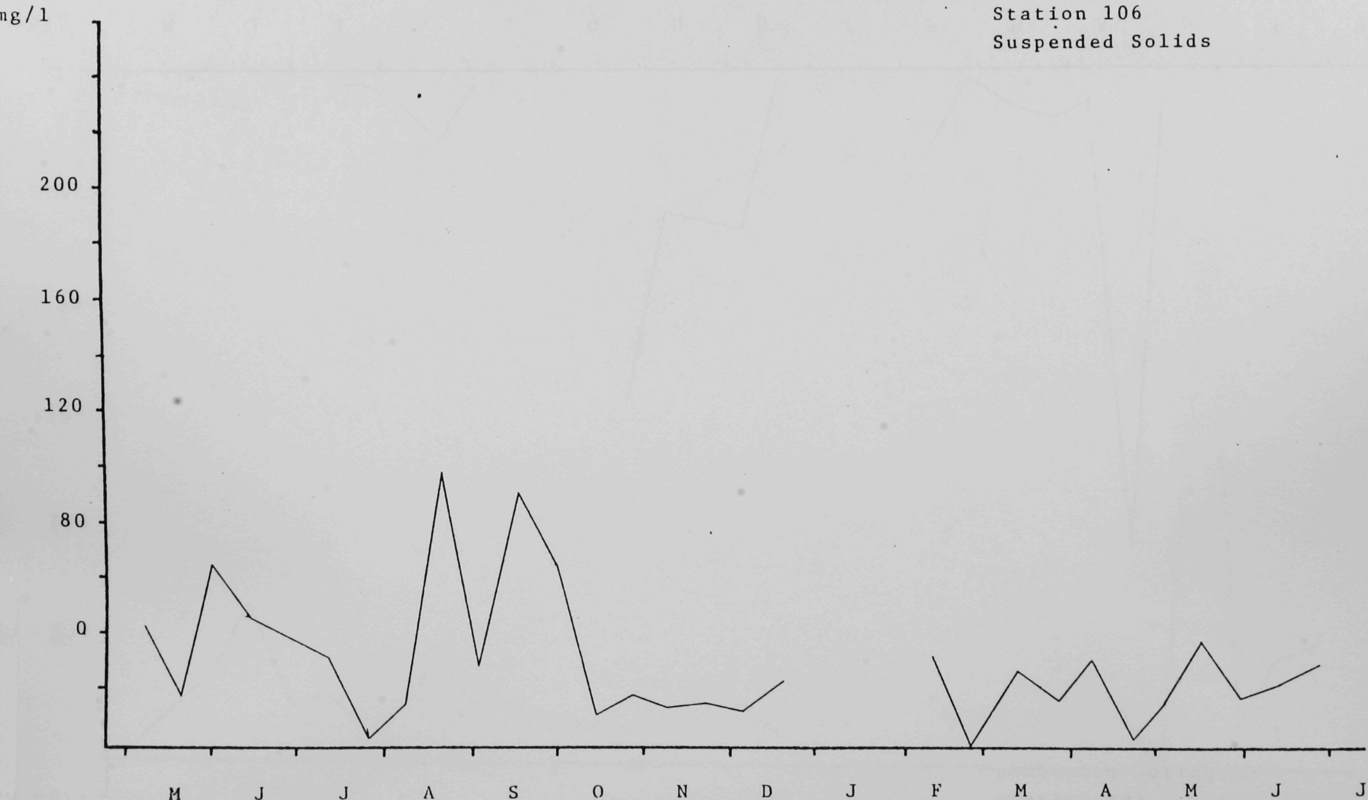

Station 101
Suspended Solids
200
160
120
80
40
M J J A S O N D J F M A M J J


Station 102
Suspended Solids
mg/l
200
160
120
80
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 103
Suspended Solids
200
160
120
80
40
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

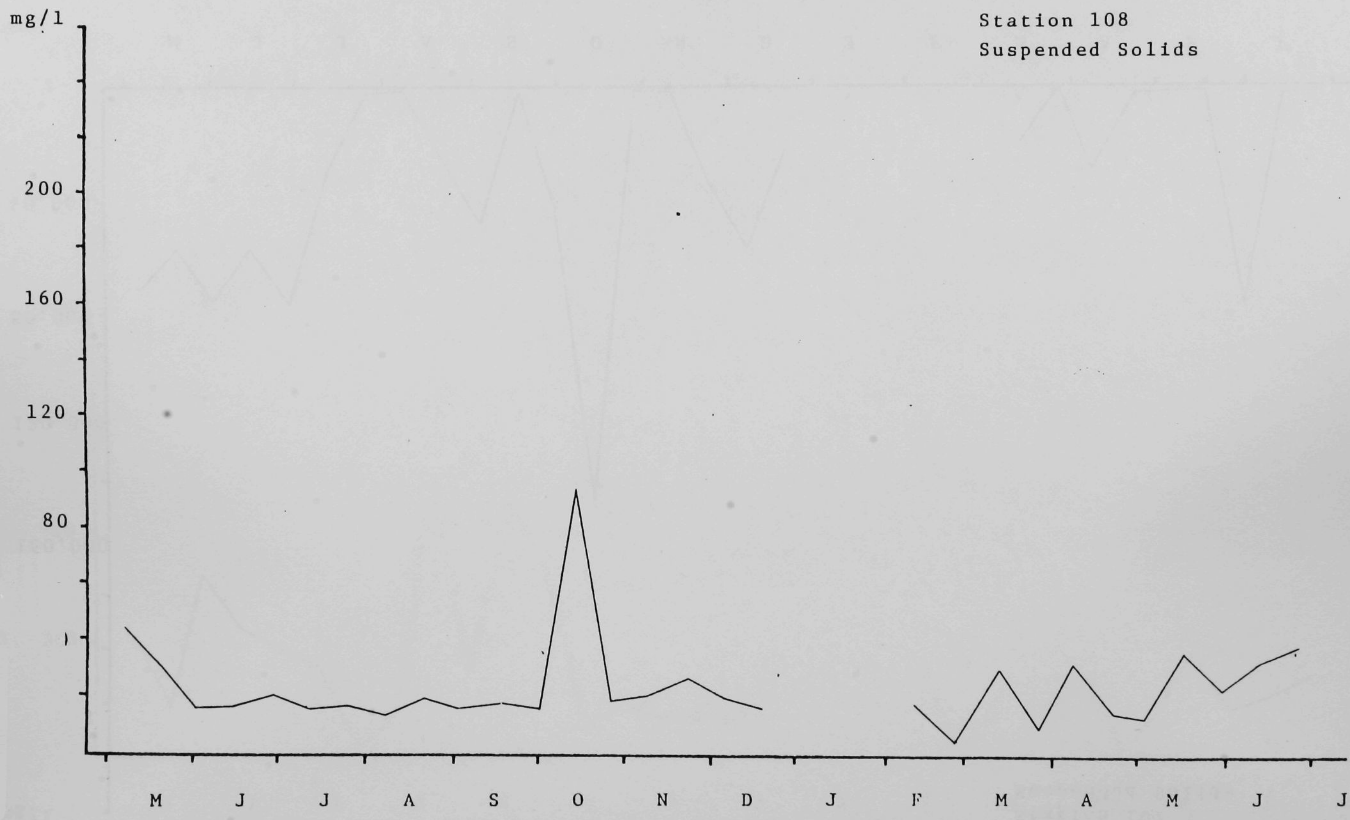

mg/1
Station 104
Suspended solids
200
160
120
80
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

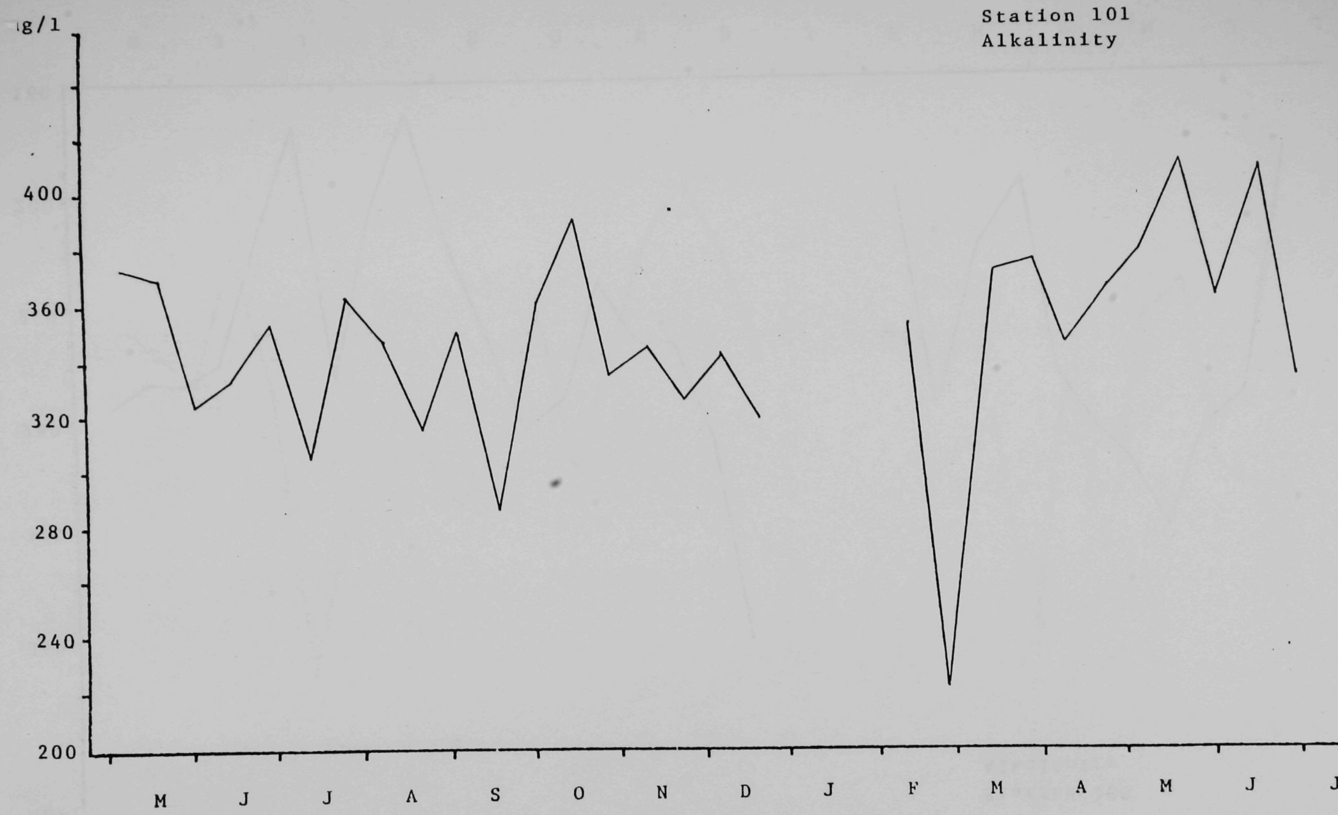

Station 105
Suspended Solids
;/1
200
160
120
80
40
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

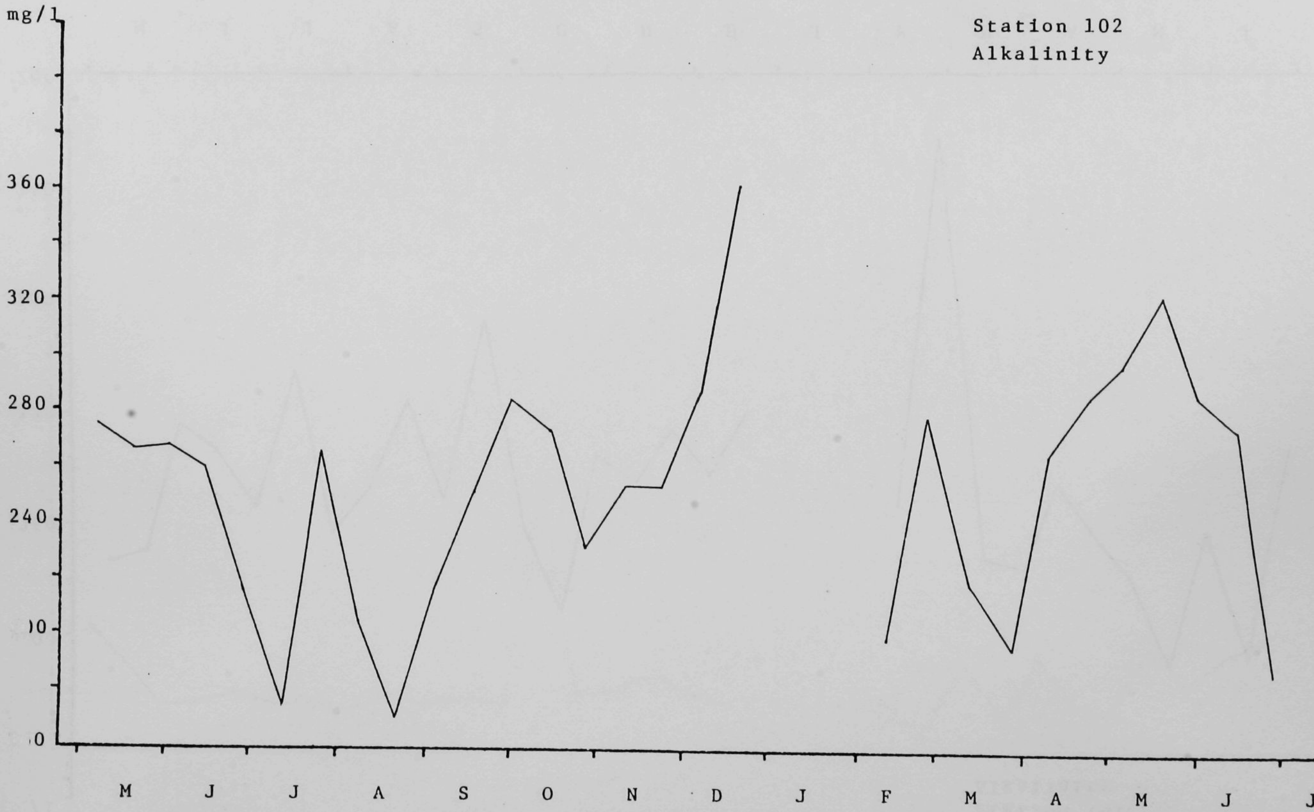

Station 106
Suspended Solids
mg/l
200
160
120
80
0
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

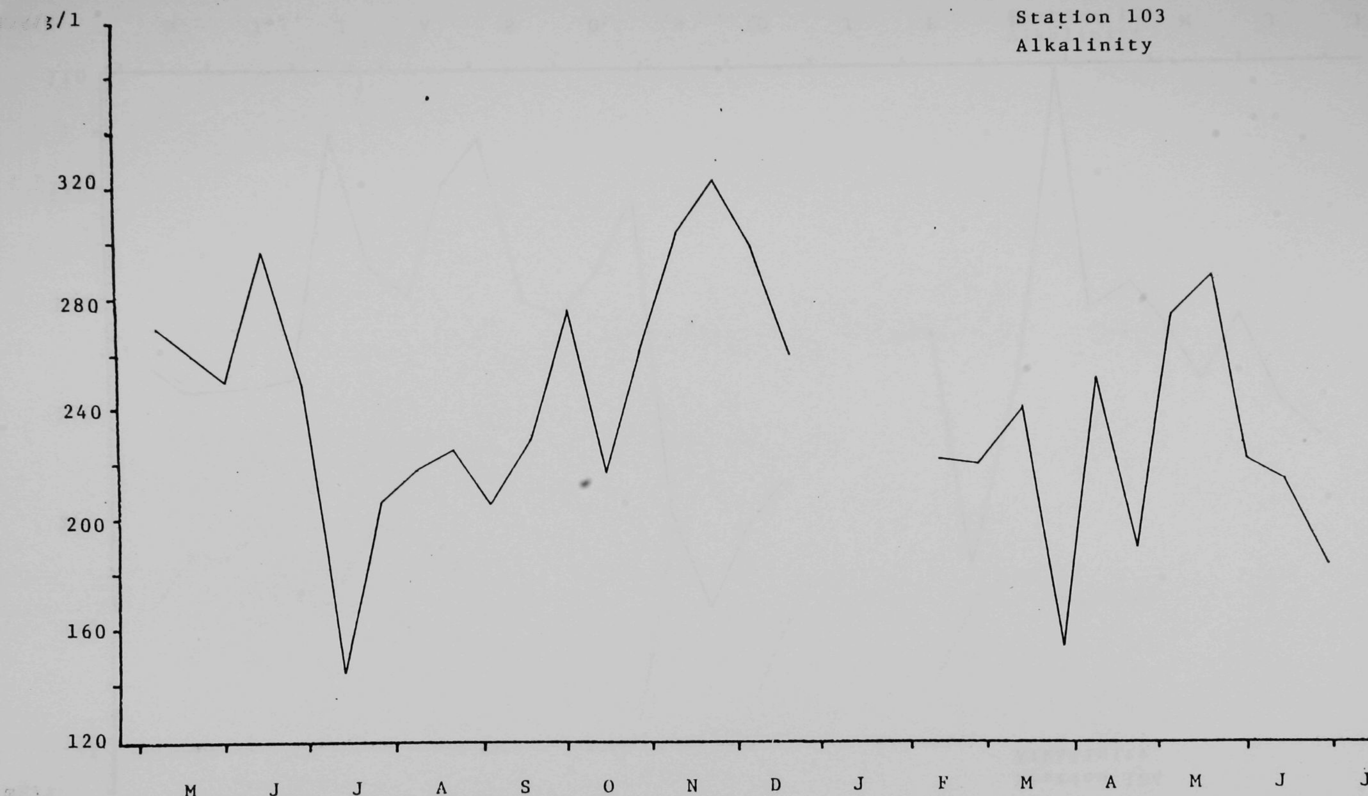
158


Station 107
Suspended Solids
L
160,000
120,000
80,000
40,000
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

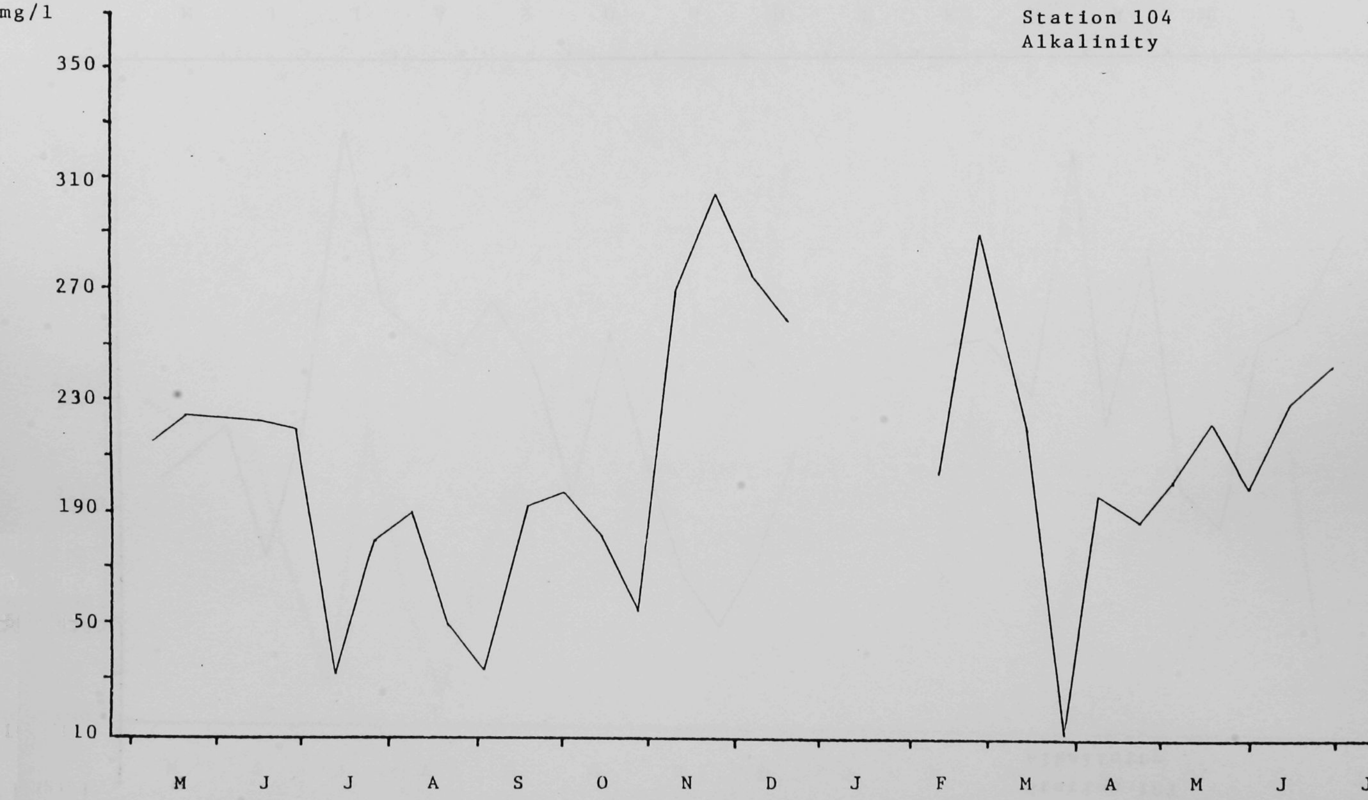

mg/l
Station 108
Suspended Solids
200
160
120
80
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

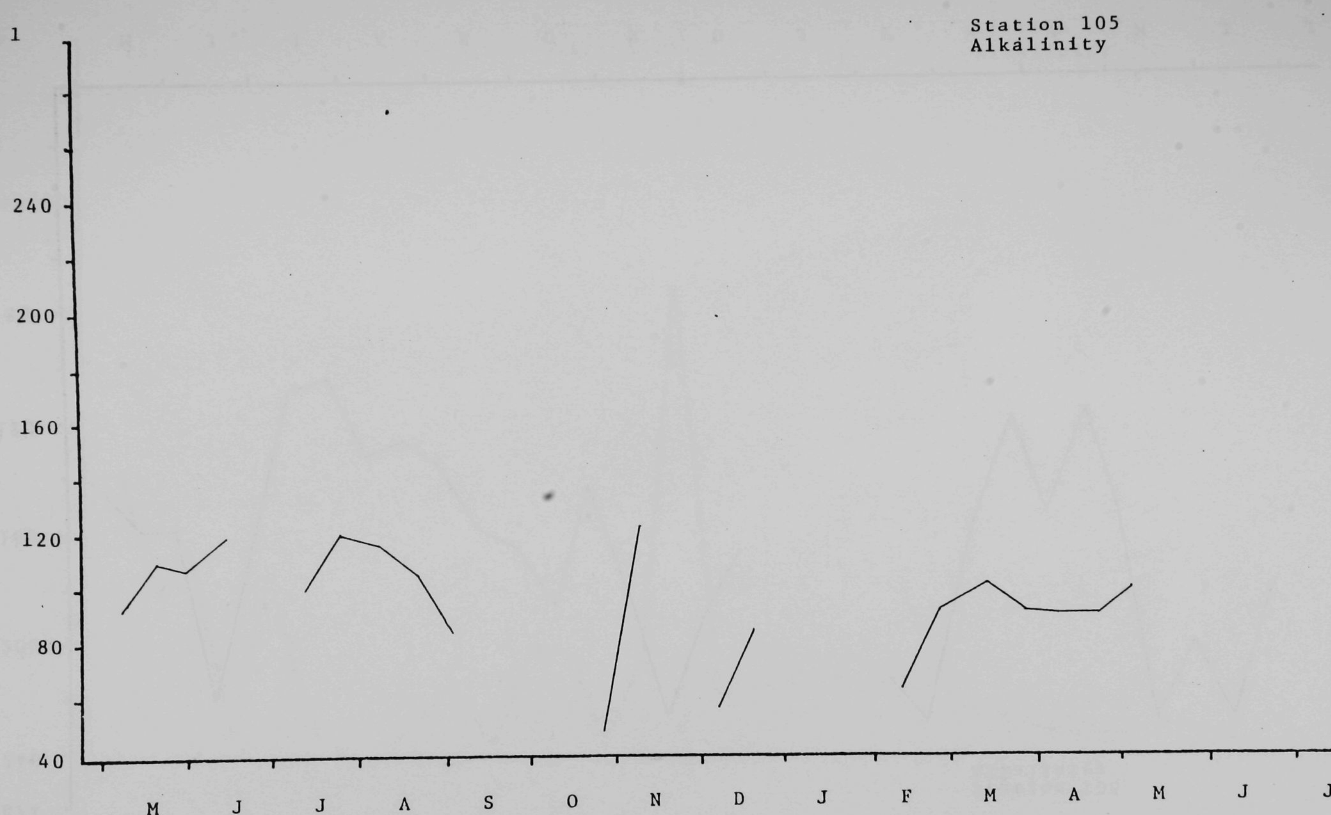

Station 101
Alkalinity
ıg/l
400
360
320
280
240
200
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

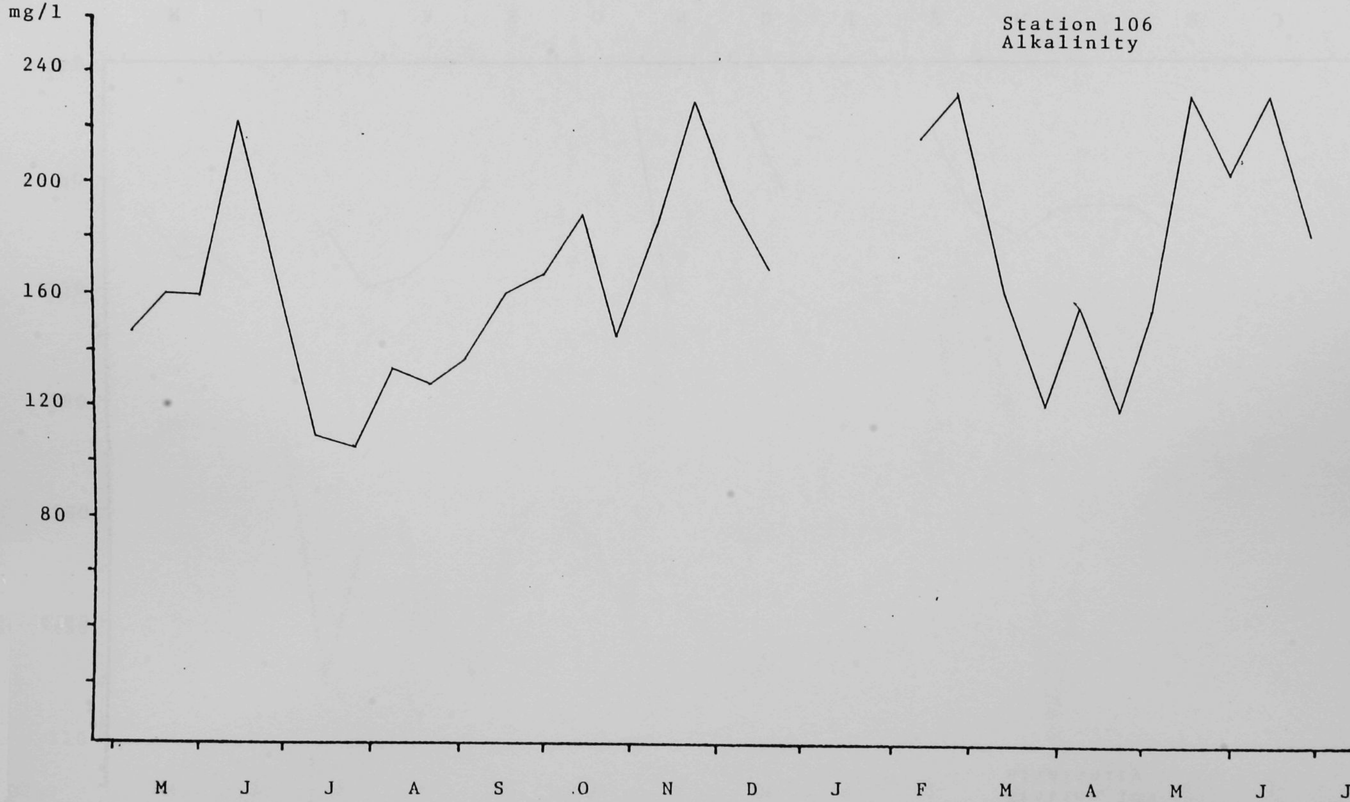

mg/1
Station 102
Alkalinity
360
320
280
240
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



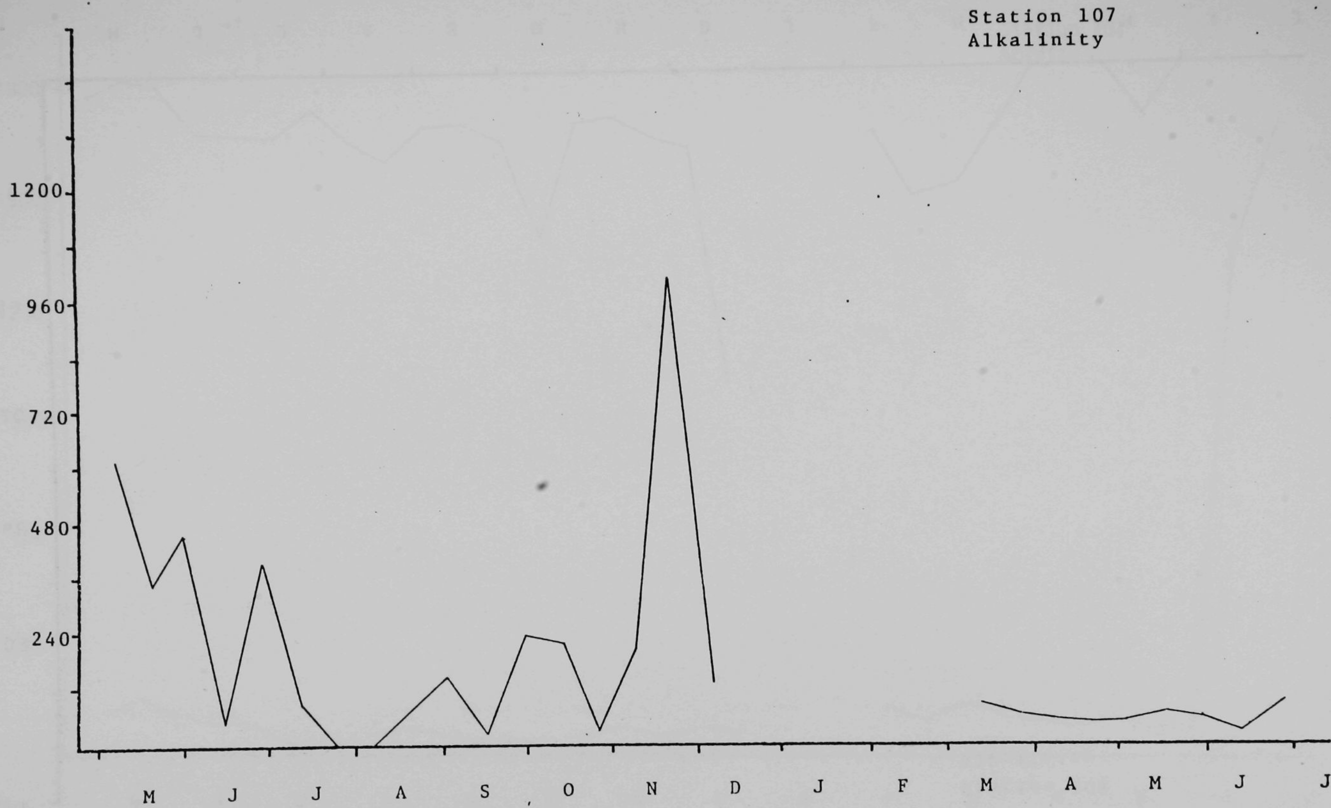
g/1
Station 103
Alkalinity
320
280
240
200
160
120
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

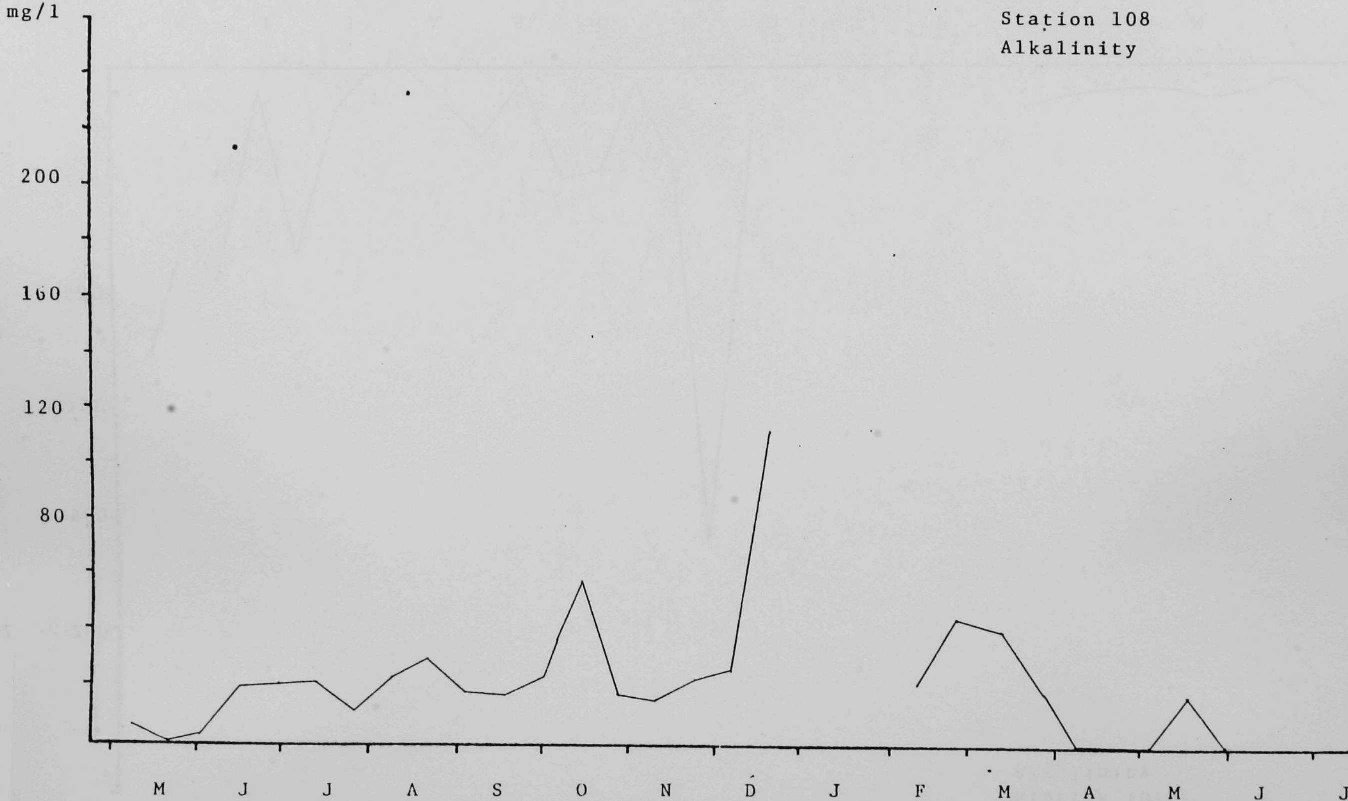

mg/l
Station 104
Alkalinity
350
310
270
230
190
50
10
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

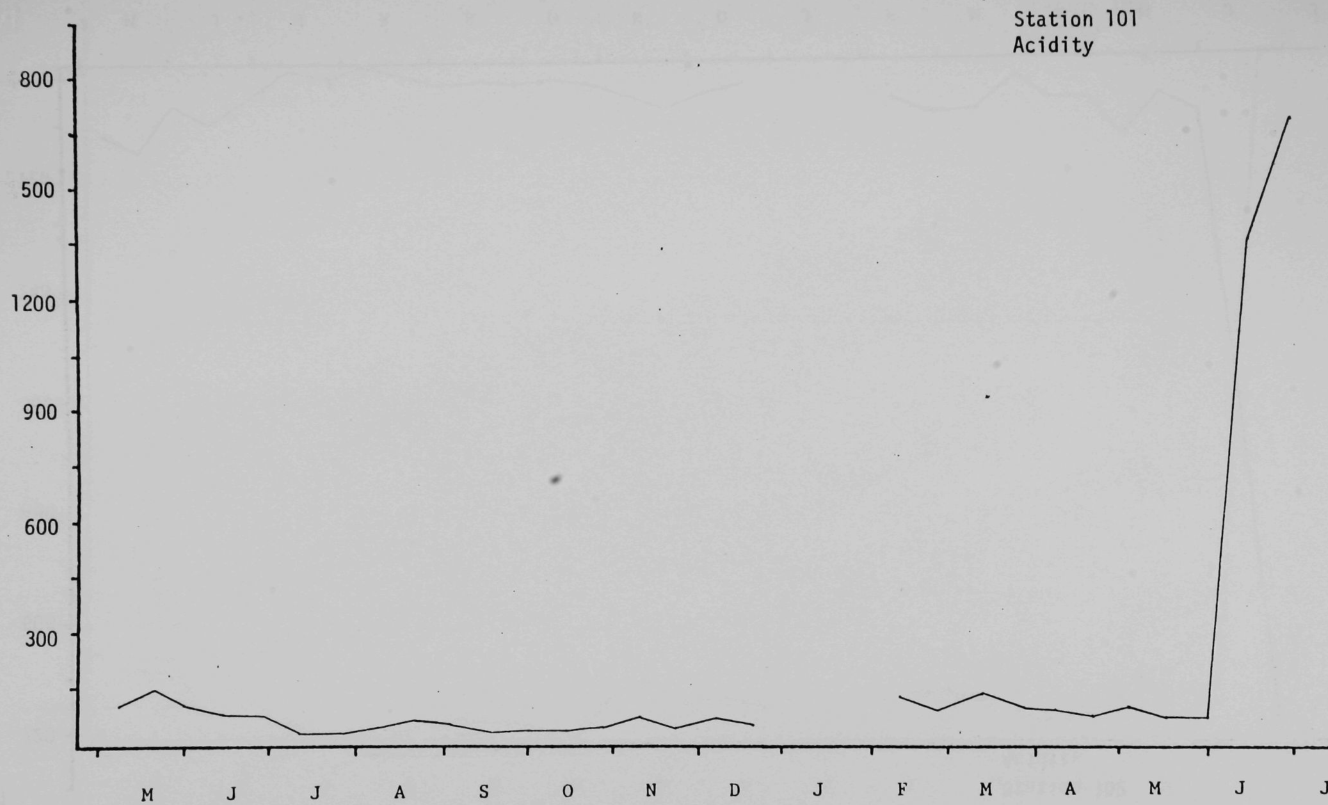

Station 105
Alkalinity
1
240
200
160
120
80
40
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

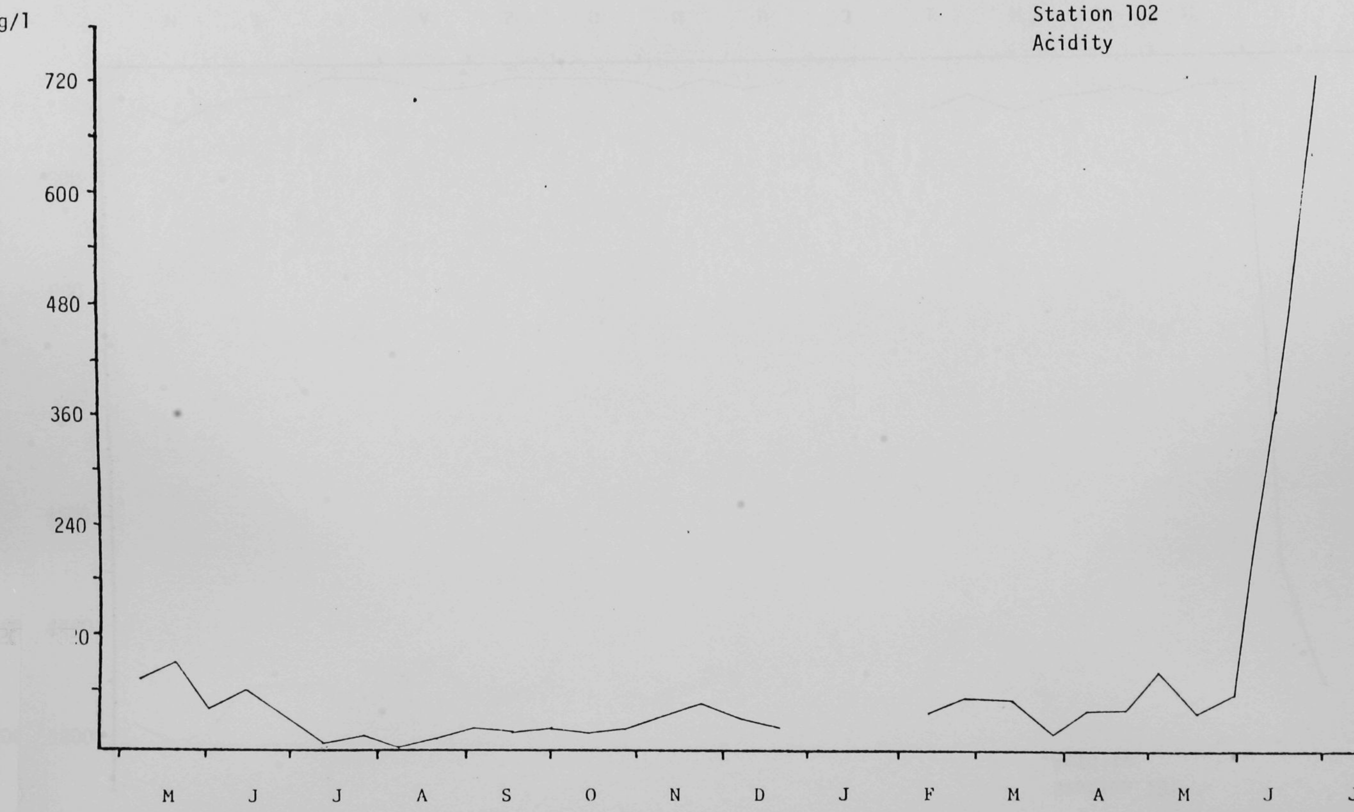


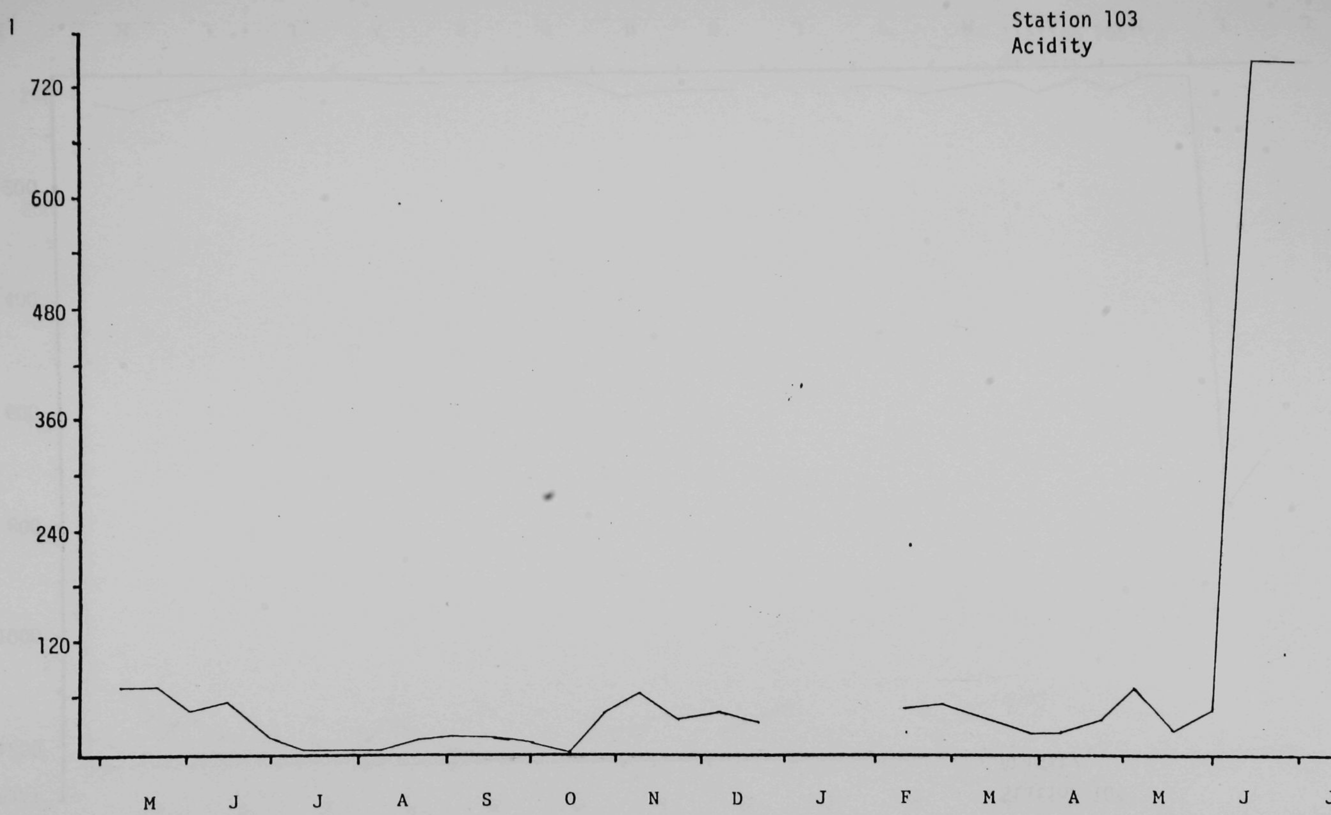
mg/l
240
200
160
120
80
Station 106
Alkalinity
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 107
Alkalinity
1200
960
720
480
240
M J J A S O N D J F M A M J J


Station 108
Alkalinity
mg/1
200
160
120
80
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

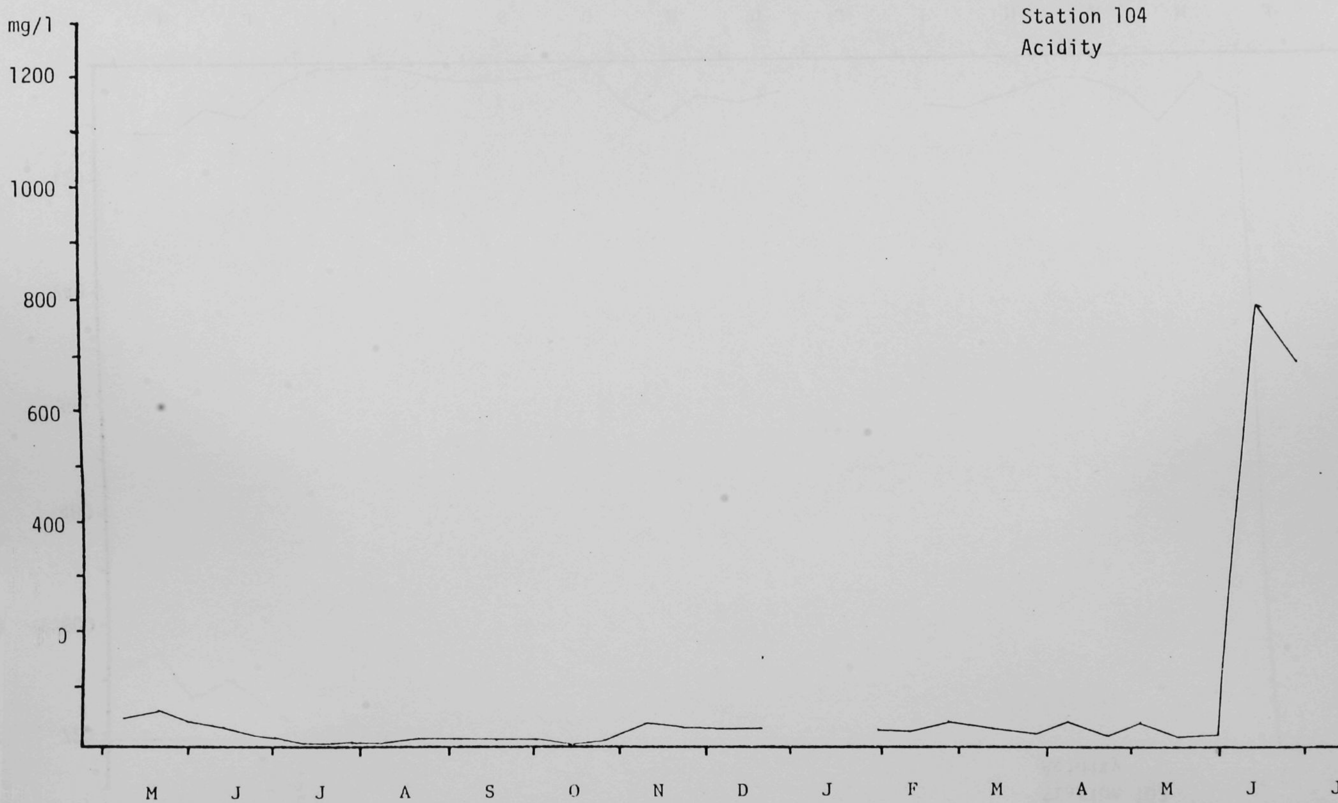

Station 101
Acidity
800
500
1200
900
600
300
M J J A S O N D J F M A M J J

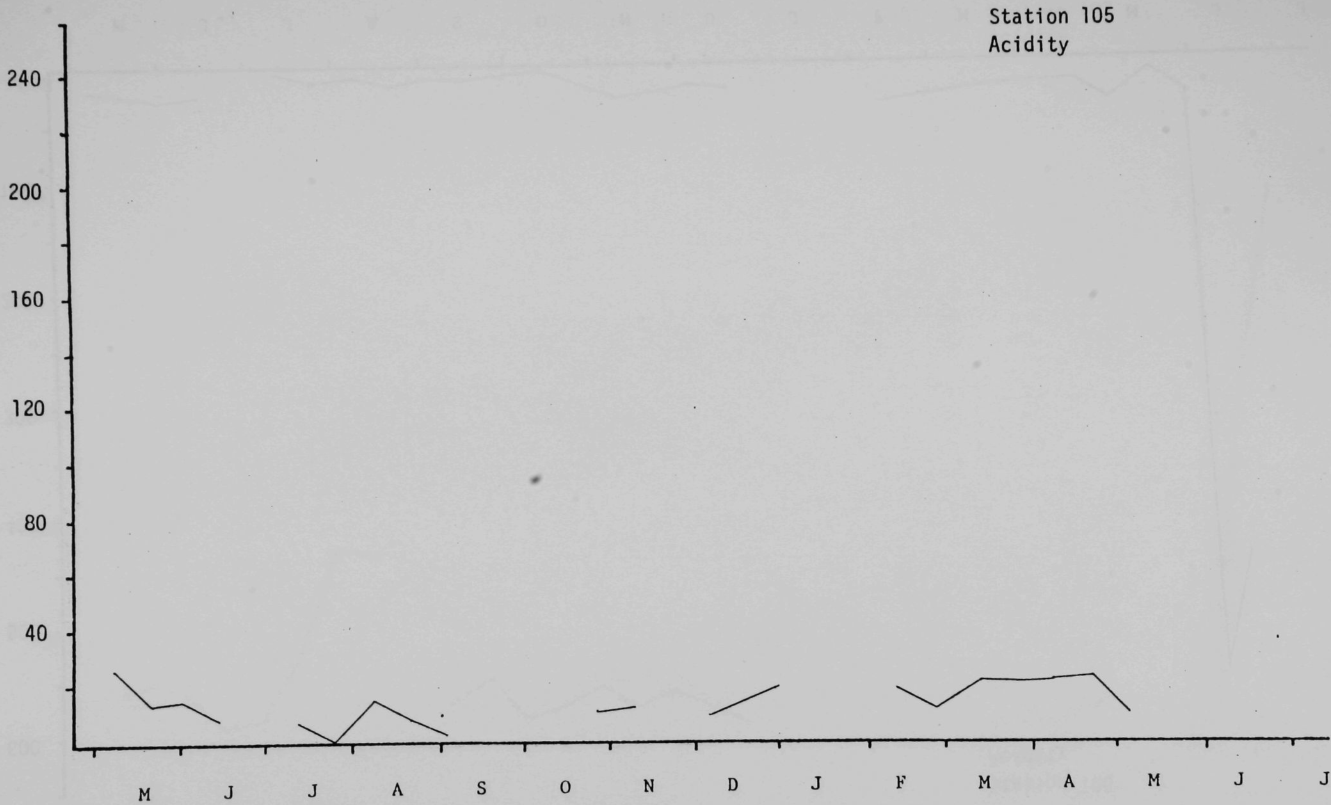

Station 102
Acidity
g/1
720
600
480
360
240
:0
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

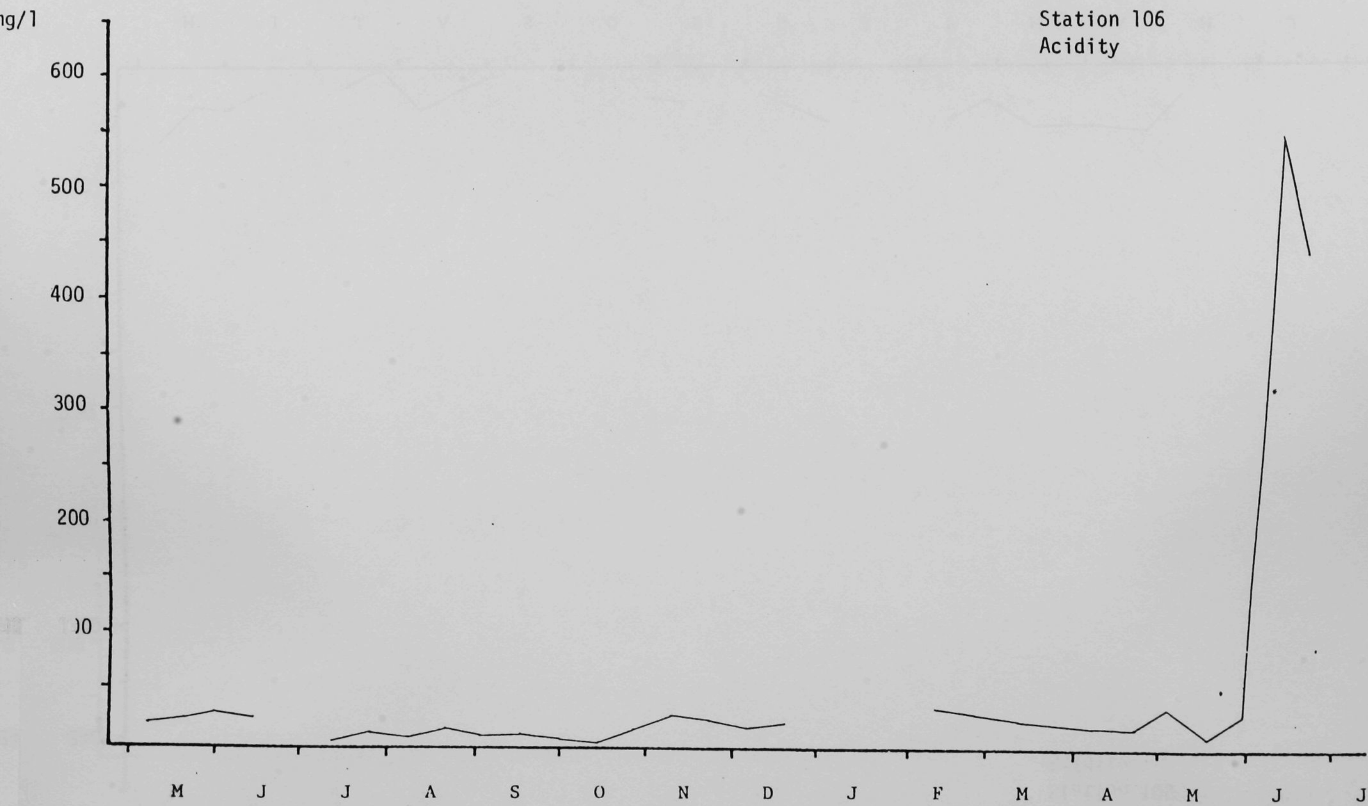


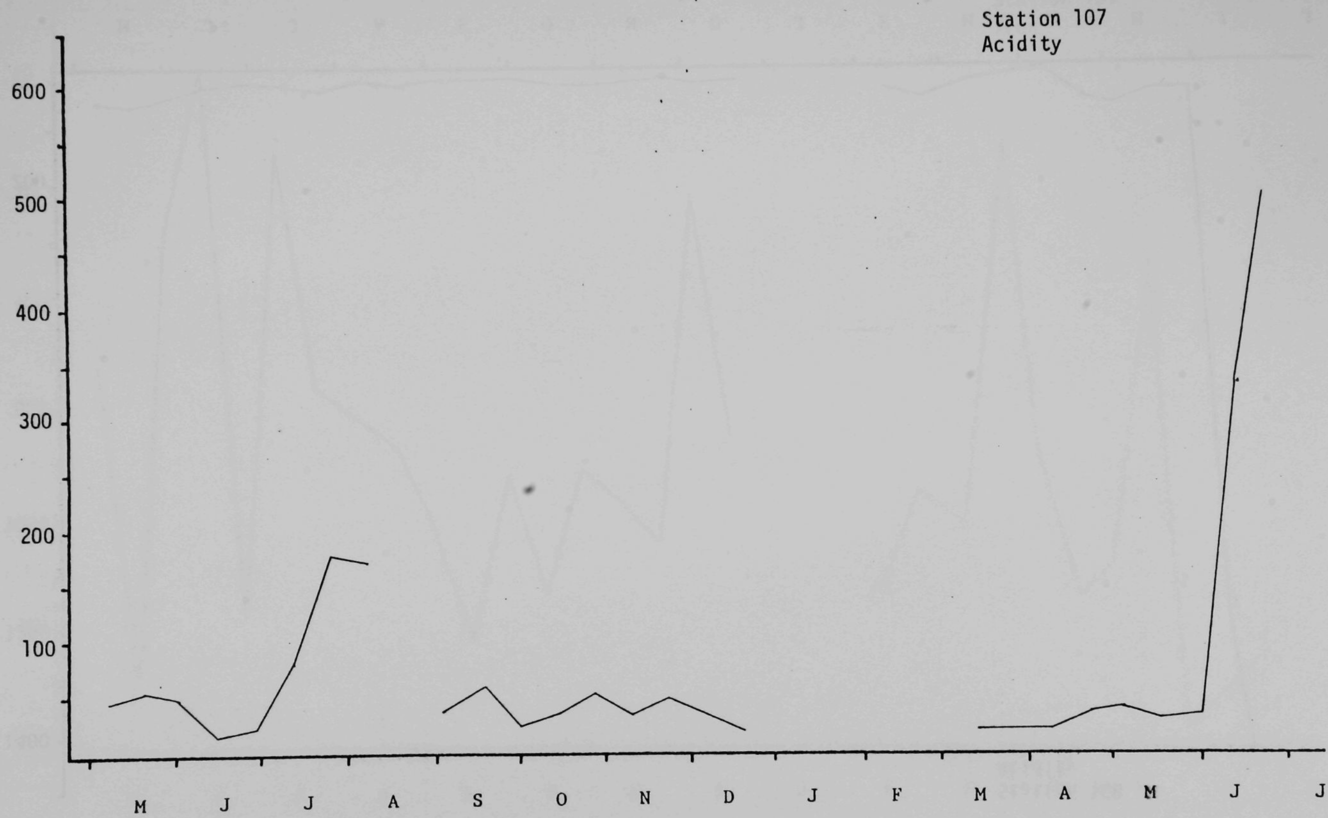
Station 103
Acidity
1
720
600
480
360
240
120
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

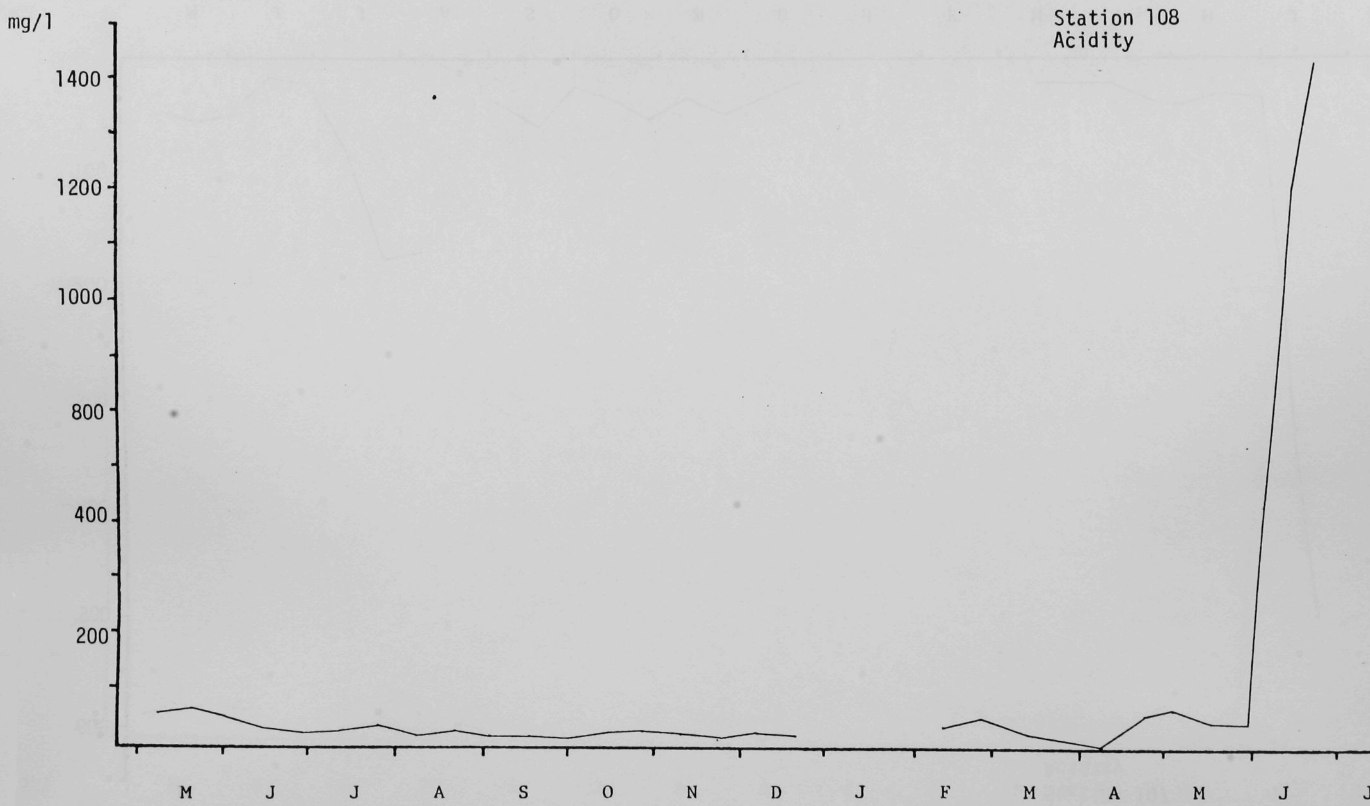
171

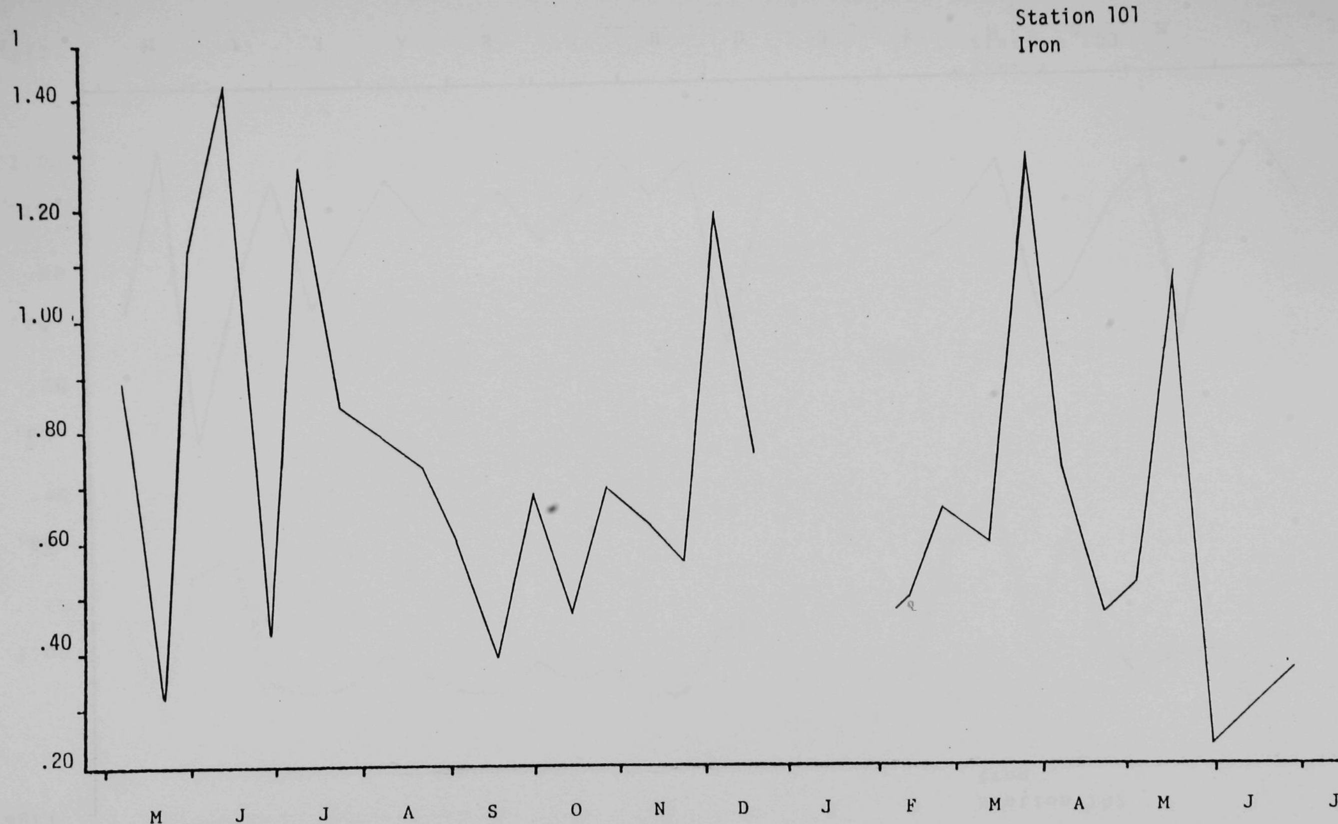

Station 104
Acidity
mg/l
1200
1000
800
600
400
M J J A S O N D J F M A M J J


Station 105
Acidity
240
200
160
120
80
40
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

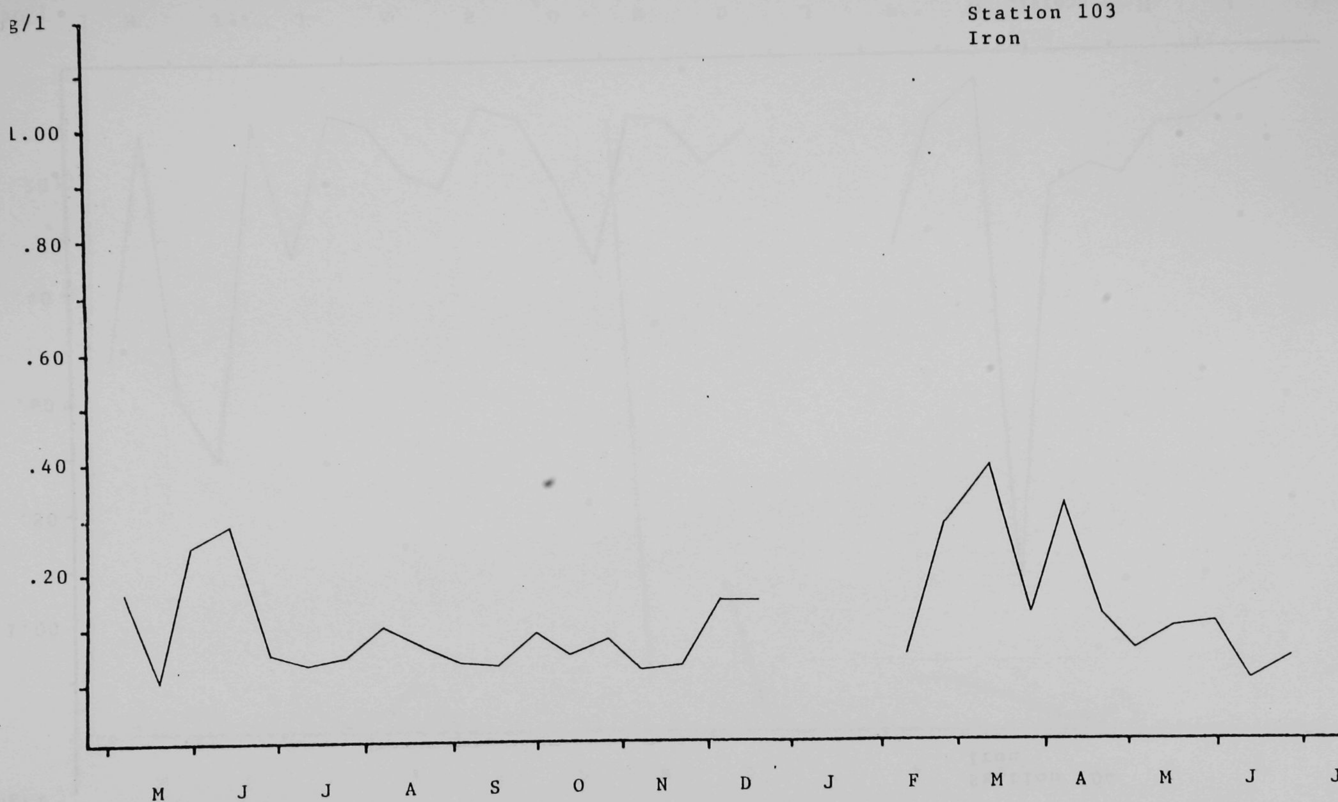

Station 106
Acidity
ng/l
600
500
400
300
200
)0
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

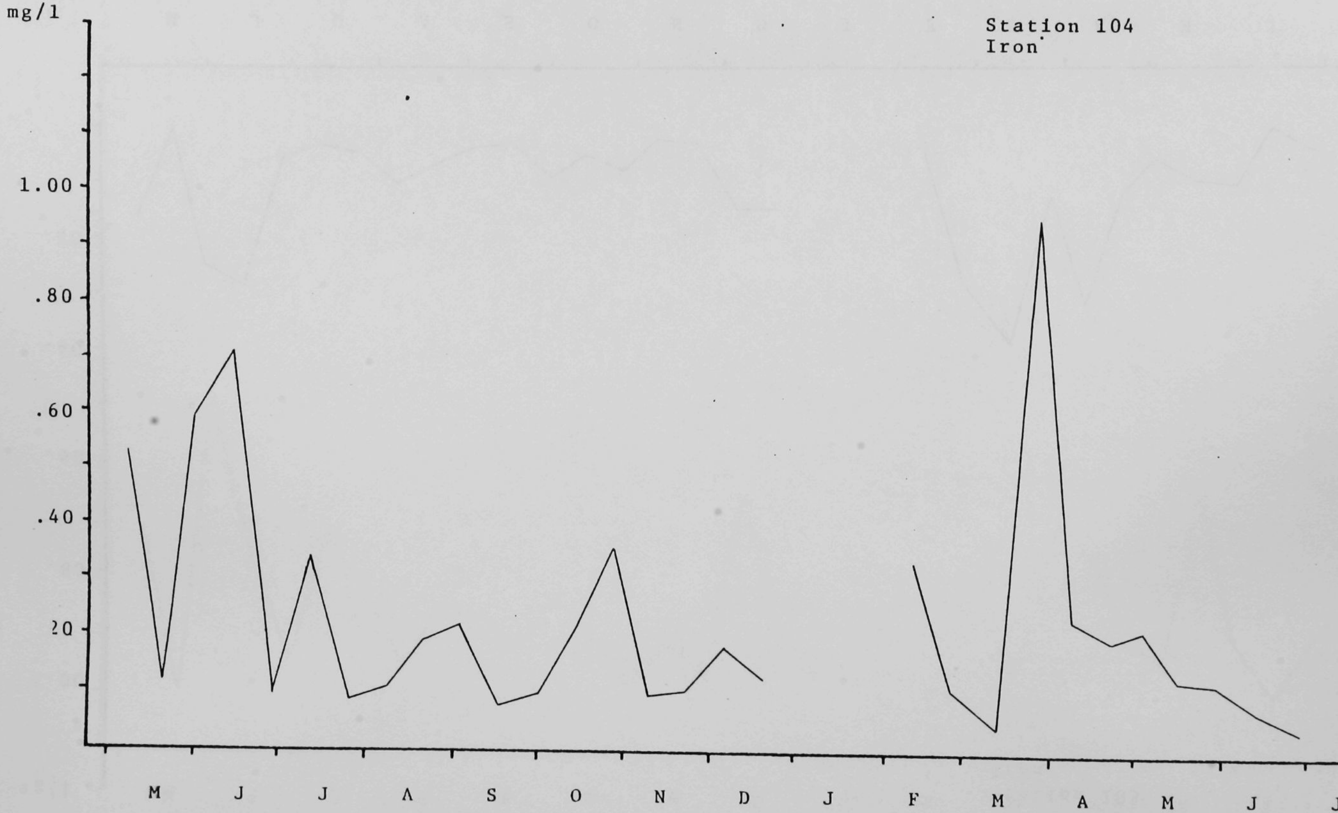

Station 107
Acidity
600
500
400
300
200
100
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 108
Acidity
mg/l
1400
1200
1000
800
400
200
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

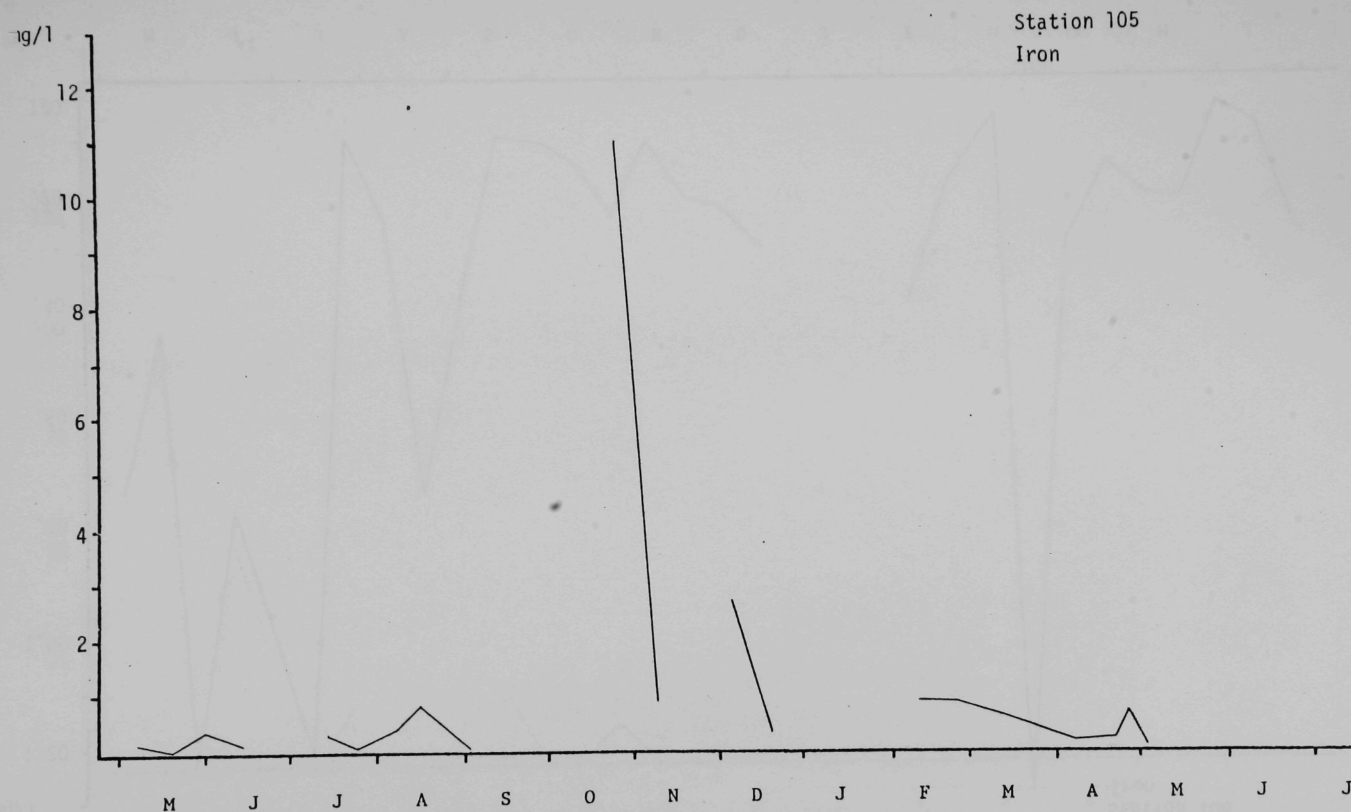

Station 101
Iron
1
1.40
1.20
1.00
.80
.60
.40
.20
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


mg/1
Station 102
Iron
1.00
.80
.60
.40
0
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

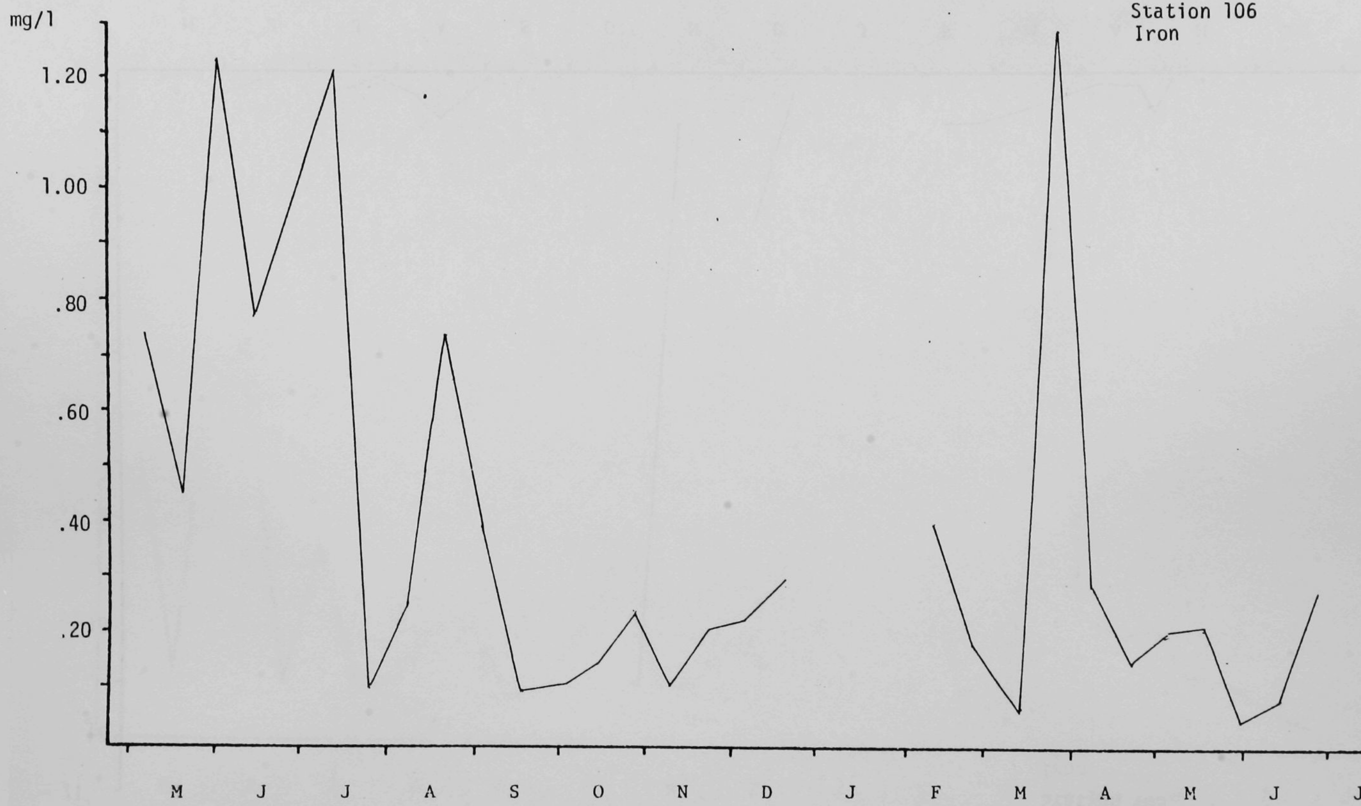

Station 103
Iron
g/1
1.00
.80
.60
.40
.20
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



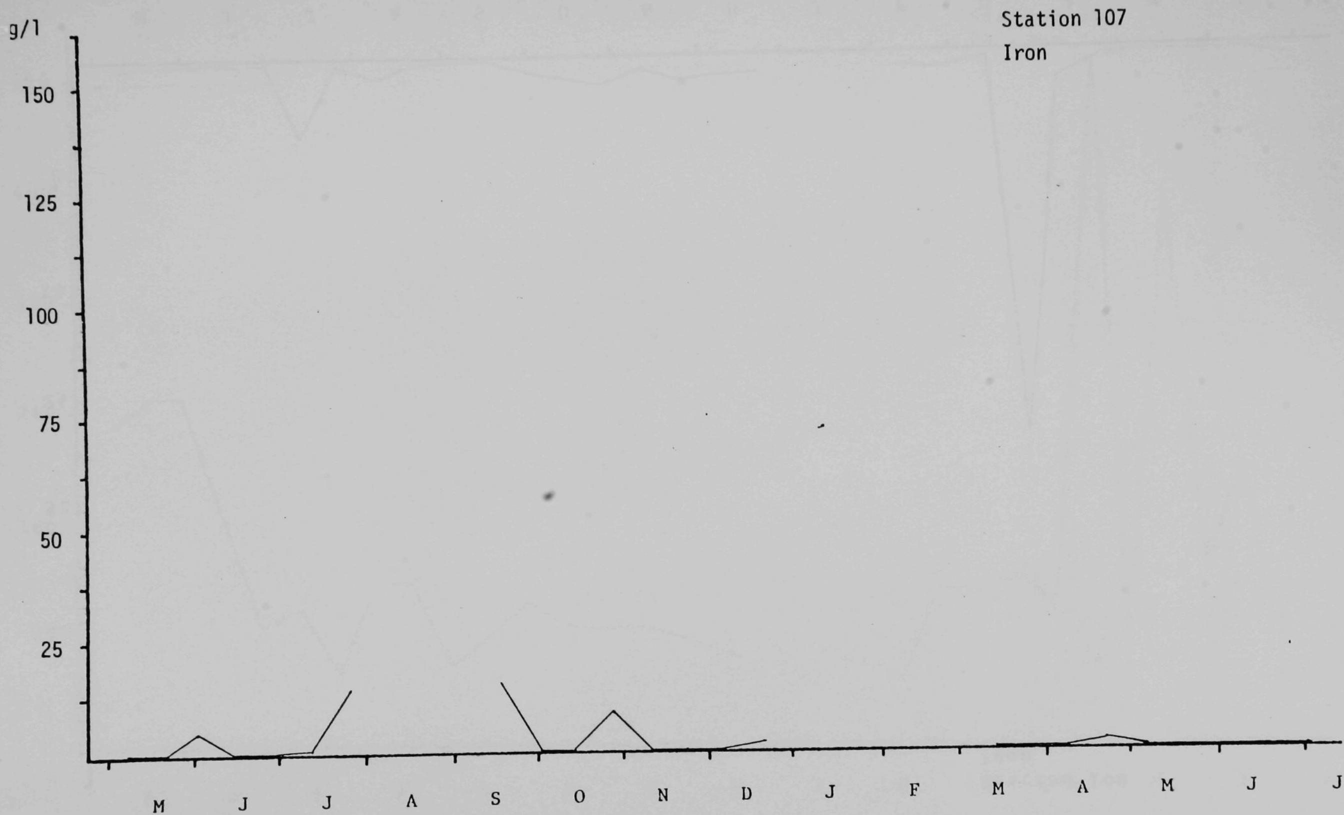
mg/l
Station 104
Iron
1.00
.80
.60
.40
20
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

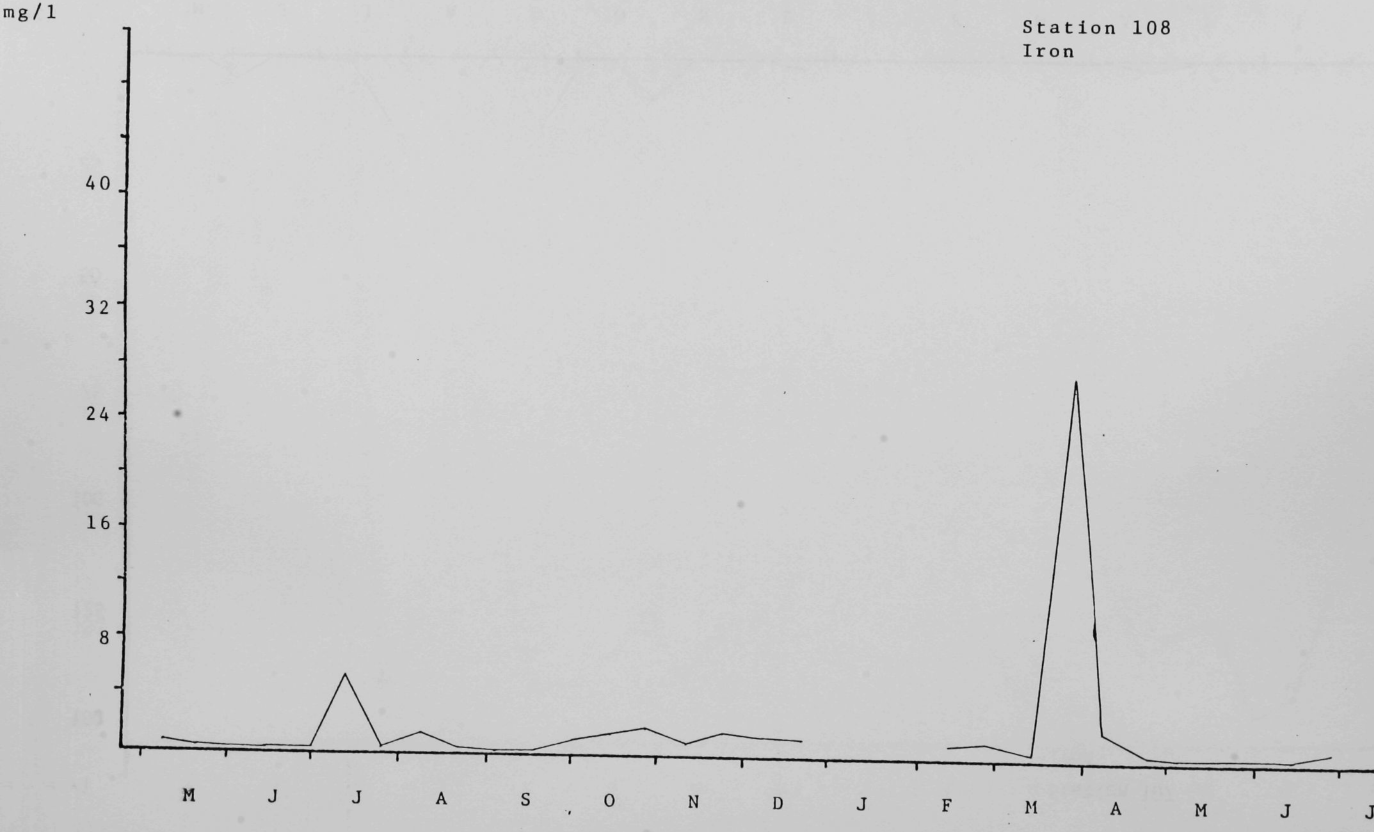


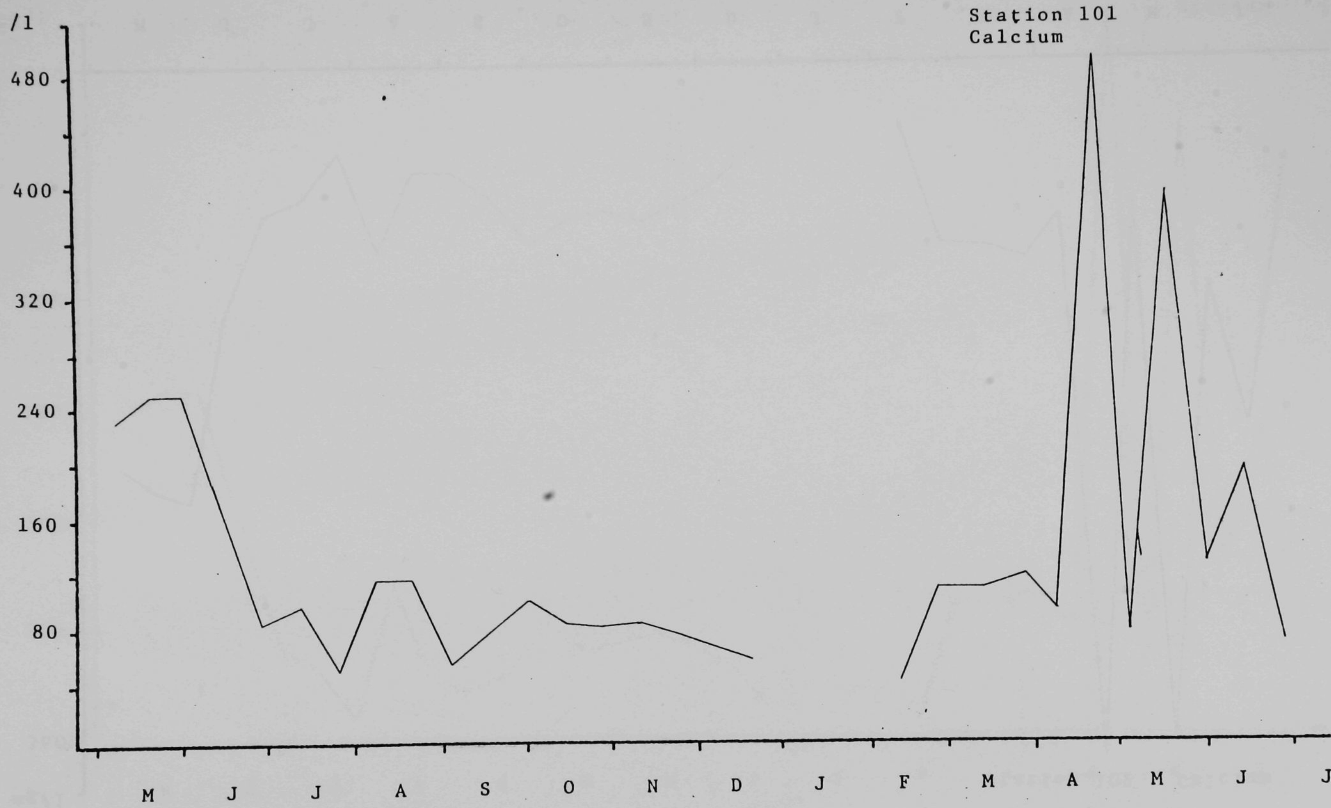
Station 105
Iron
mg/l
12
10
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



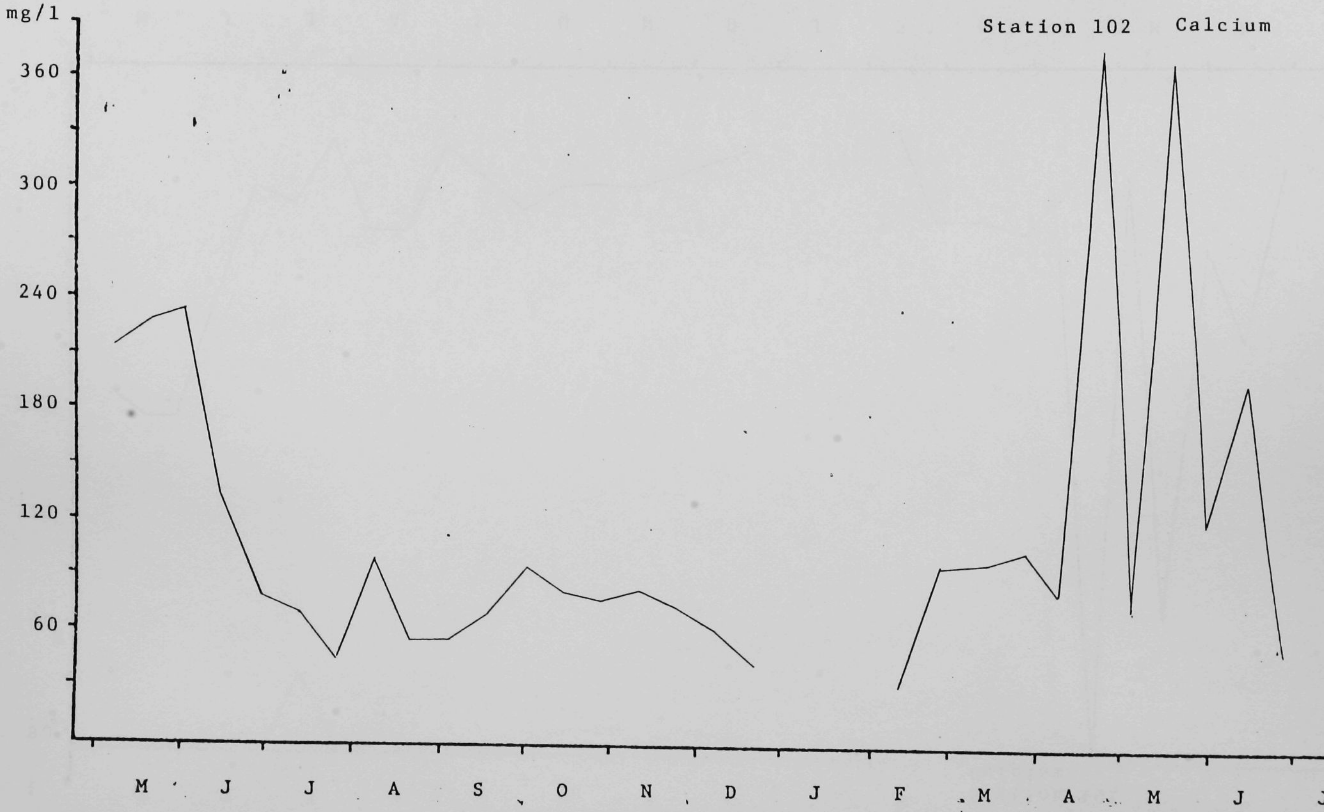
Station 106
Iron
mg/l
1.20
1.00
.80
.60
.40
.20
M J J A S O N D J F M A M J J


Station 107
Iron
g/l
150
125
100
75
50
25
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

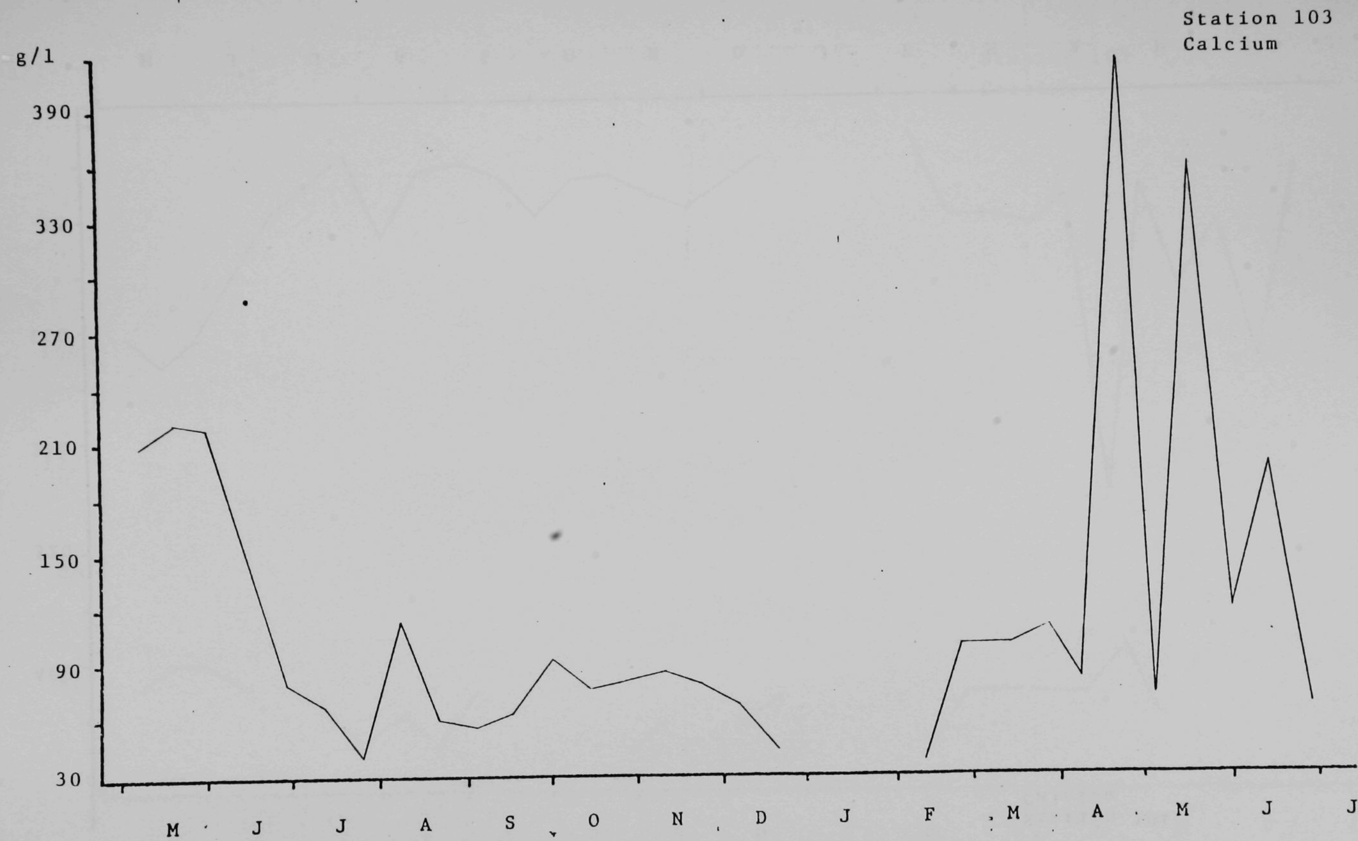

mg/1
Station 108
Iron
40
32
24
16
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

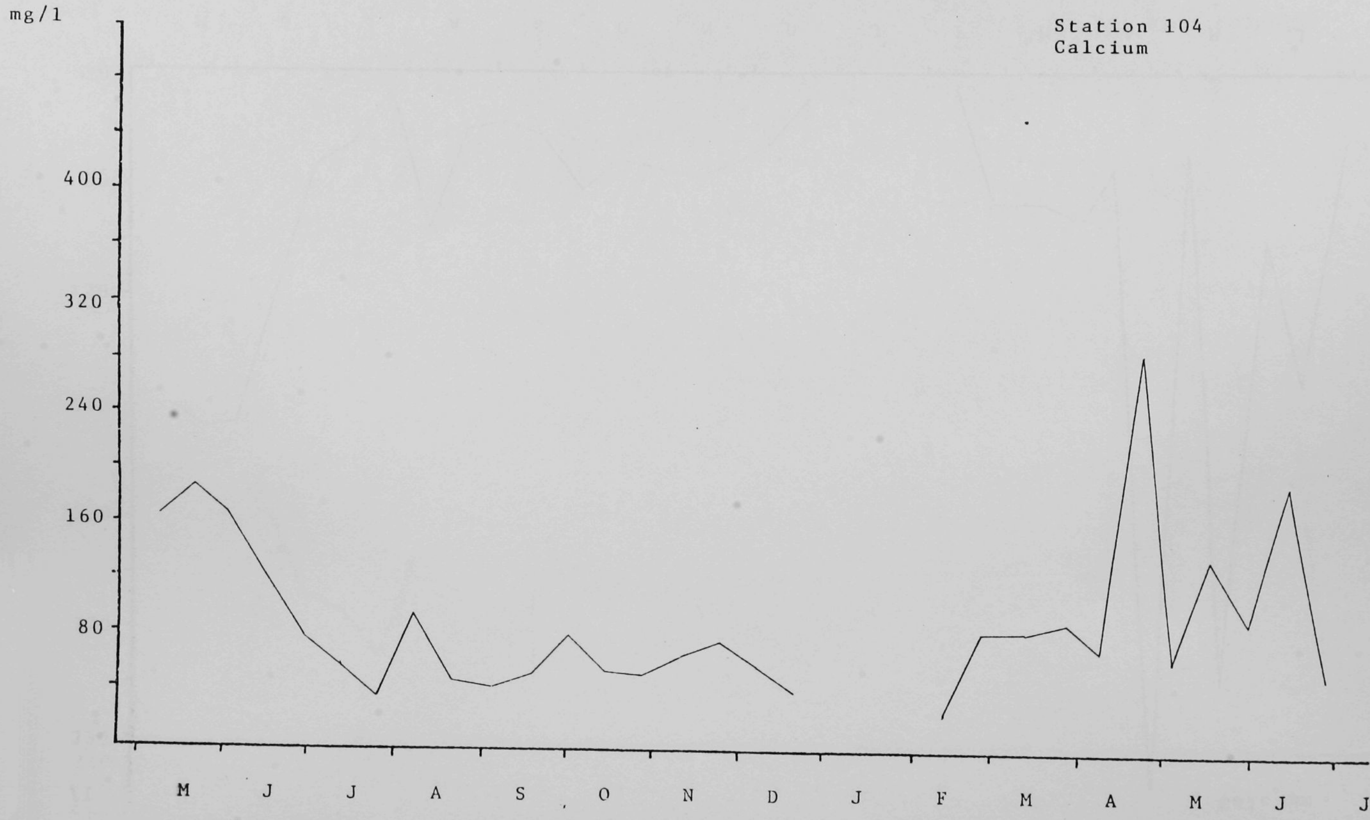

Station 101
Calcium
/l
480
400
320
240
160
80
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

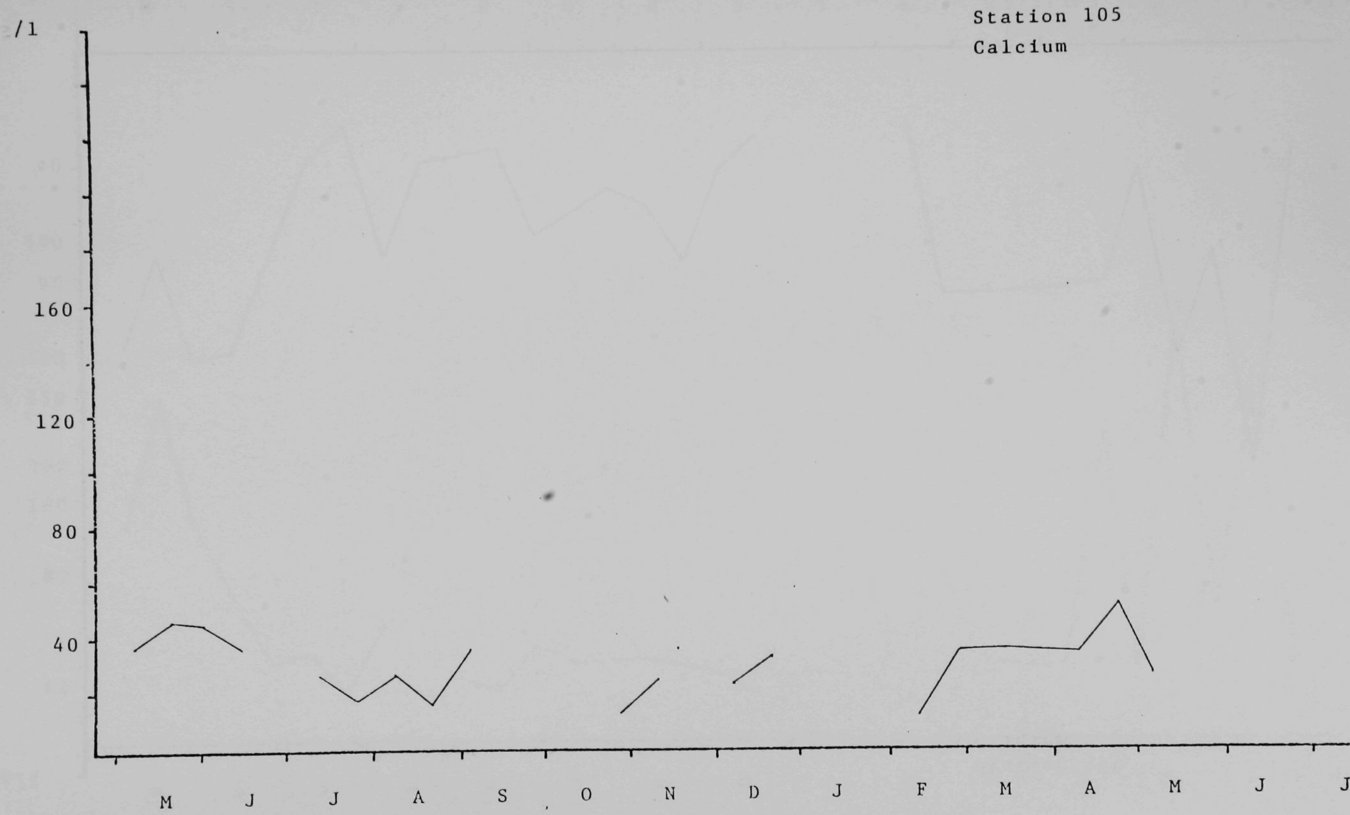
185

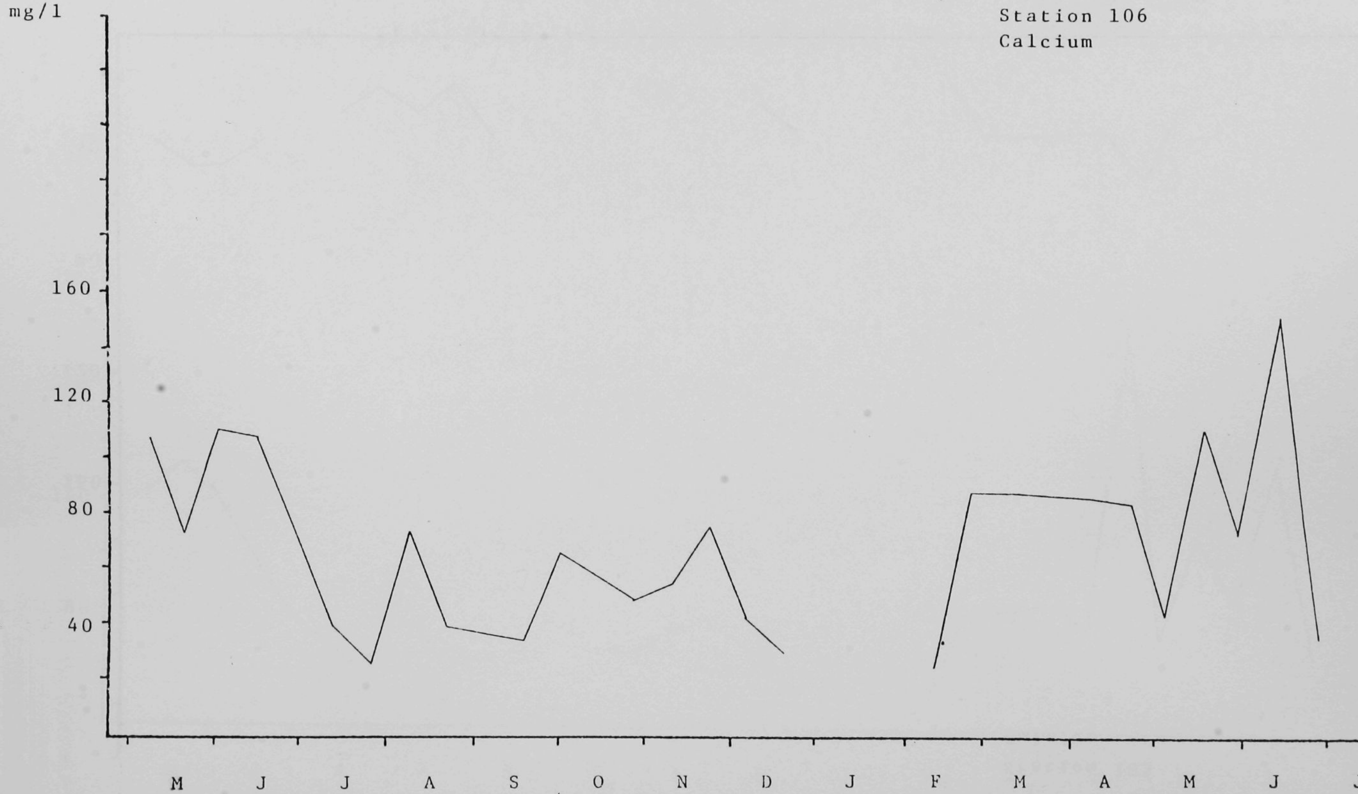

Station 102 Calcium
mg/1
360
300
240
180
120
60
M J J A S O N D J F M A M J J

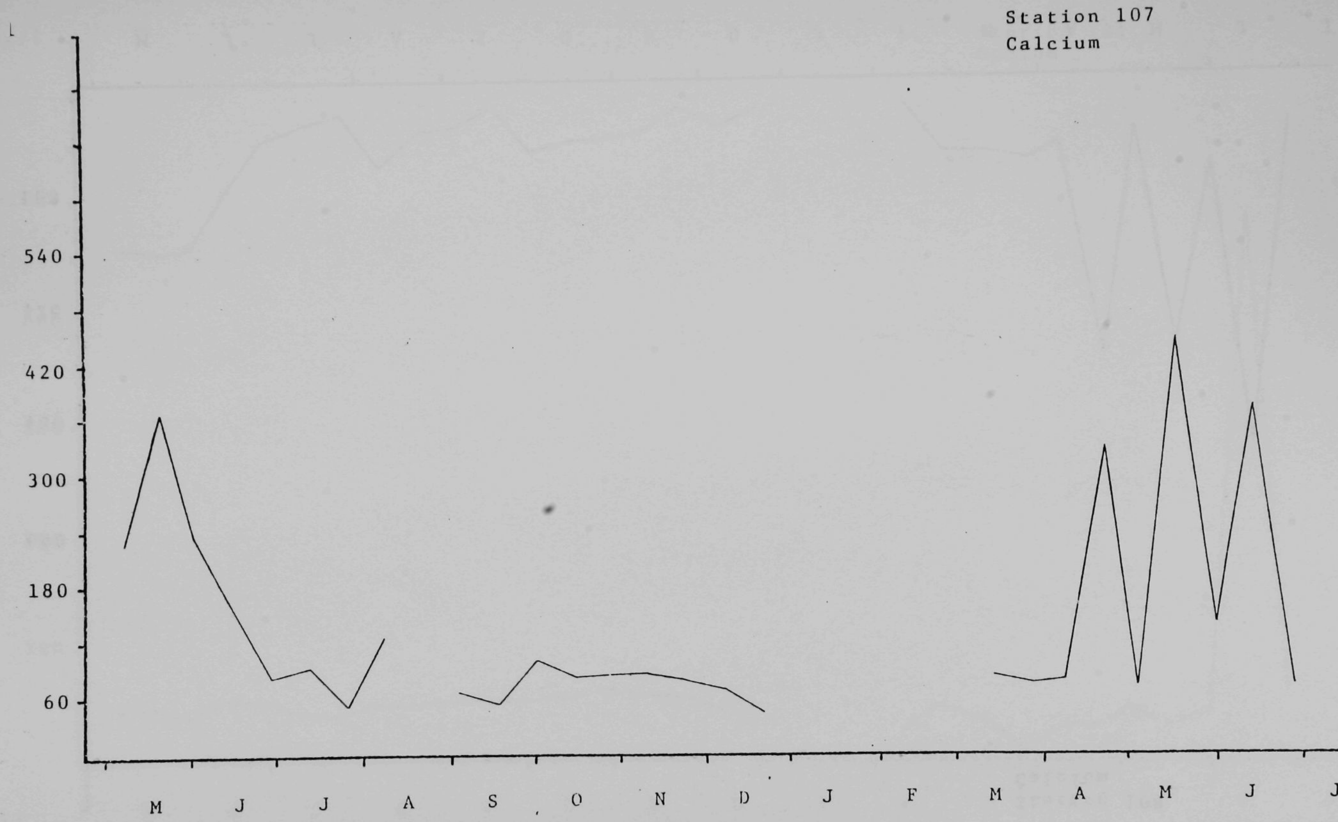
186

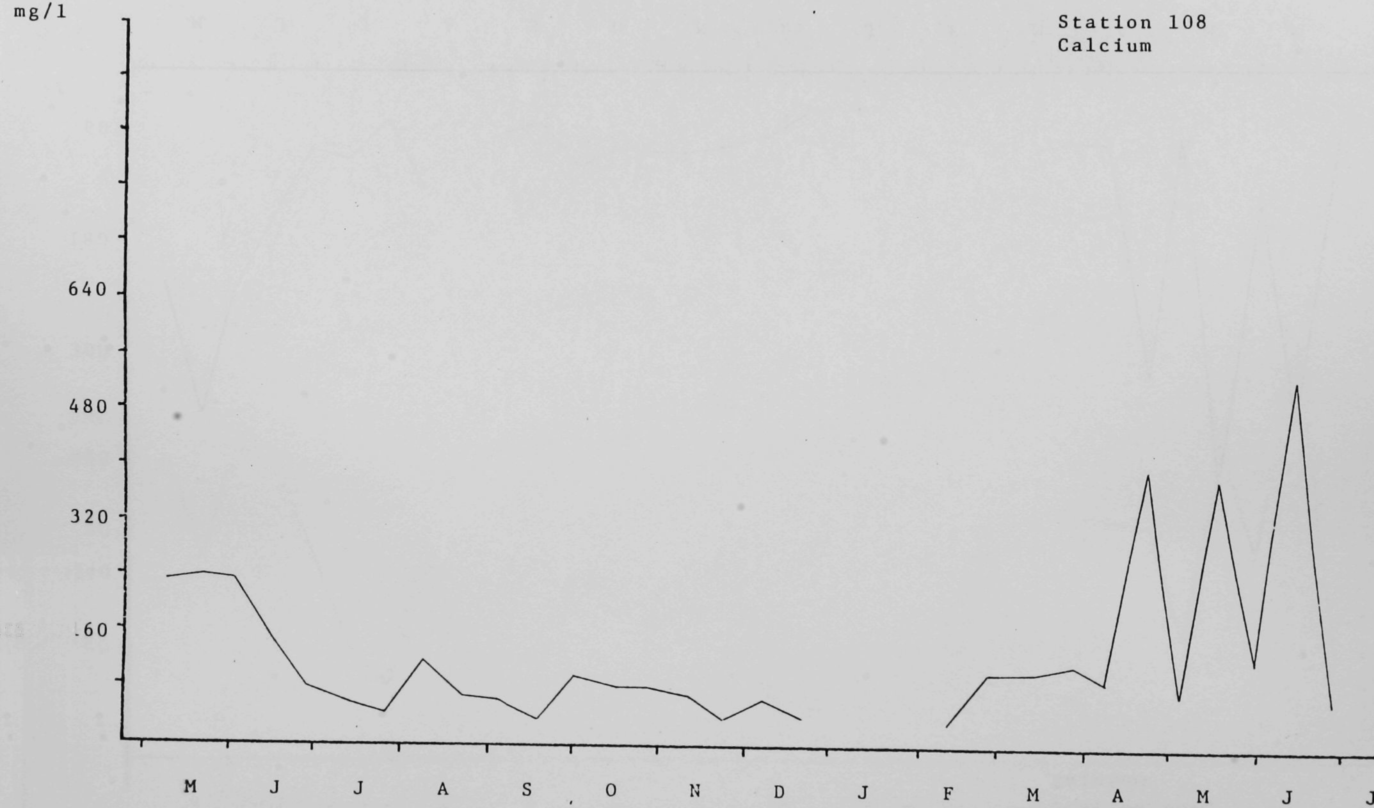

Station 103
Calcium
g/l
390
330
270
210
150
90
30
M J J A S O N D J F M A M J J


mg/1
Station 104
Calcium
400
320
240
160
80
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

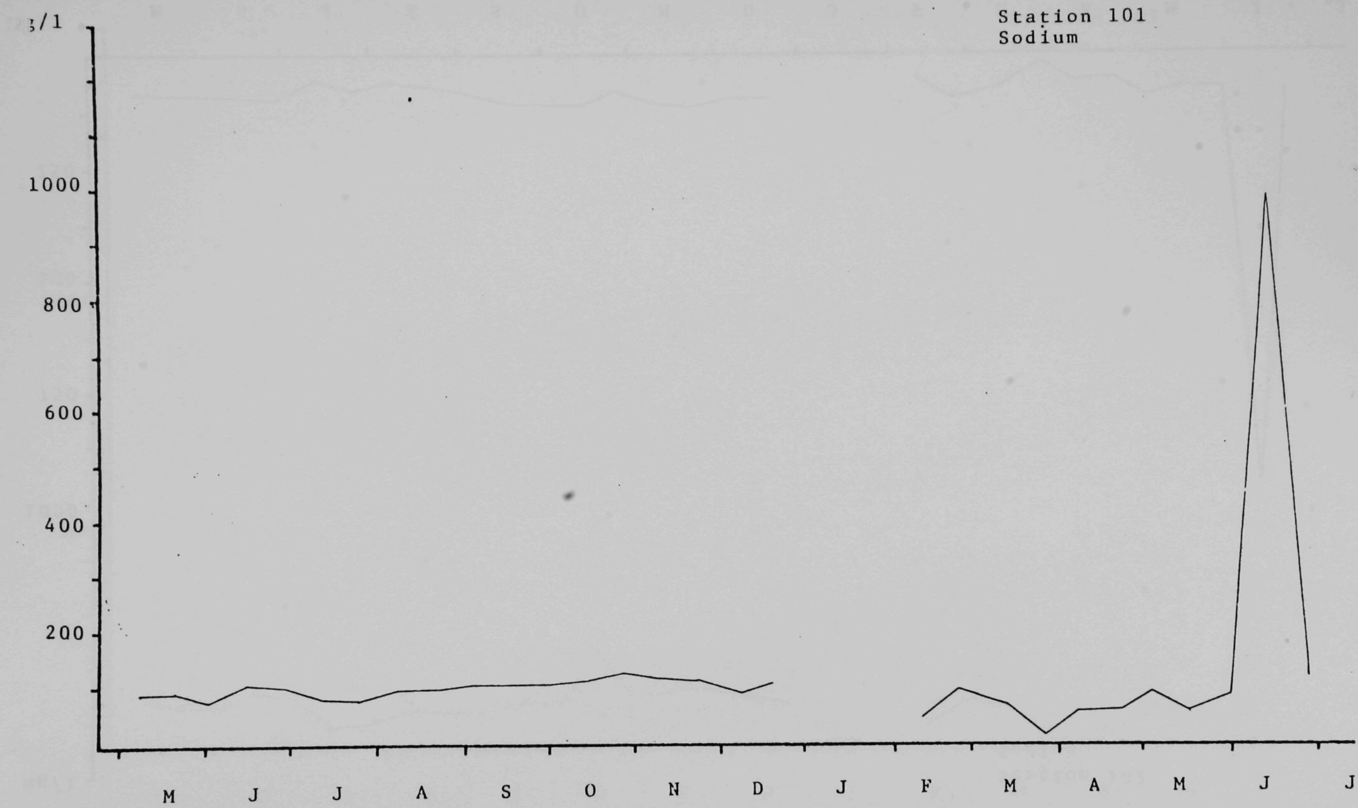

Station 105
Calcium
/l
160
120
80
40
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


mg/1
Station 106
Calcium
160
120
80
40
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

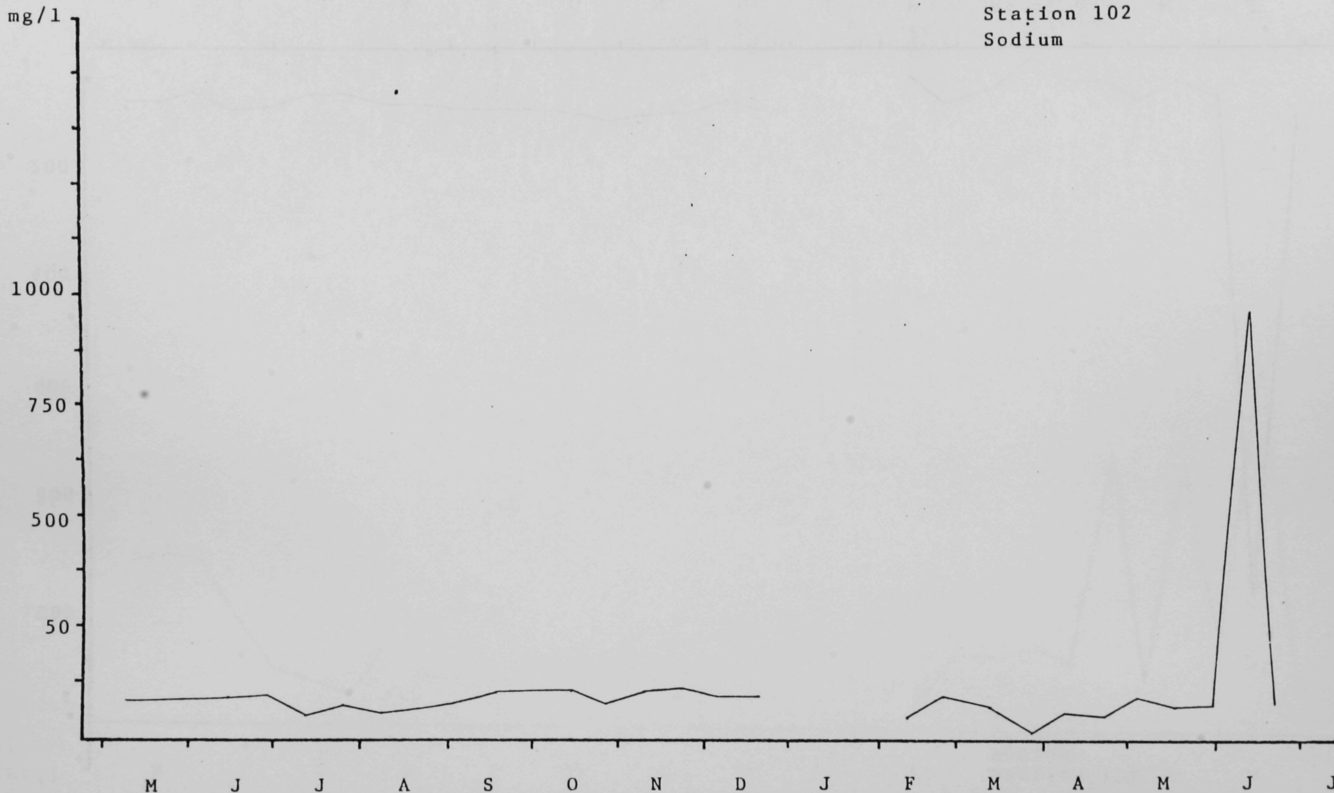

Station 107
Calcium
540
420
300
180
60
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

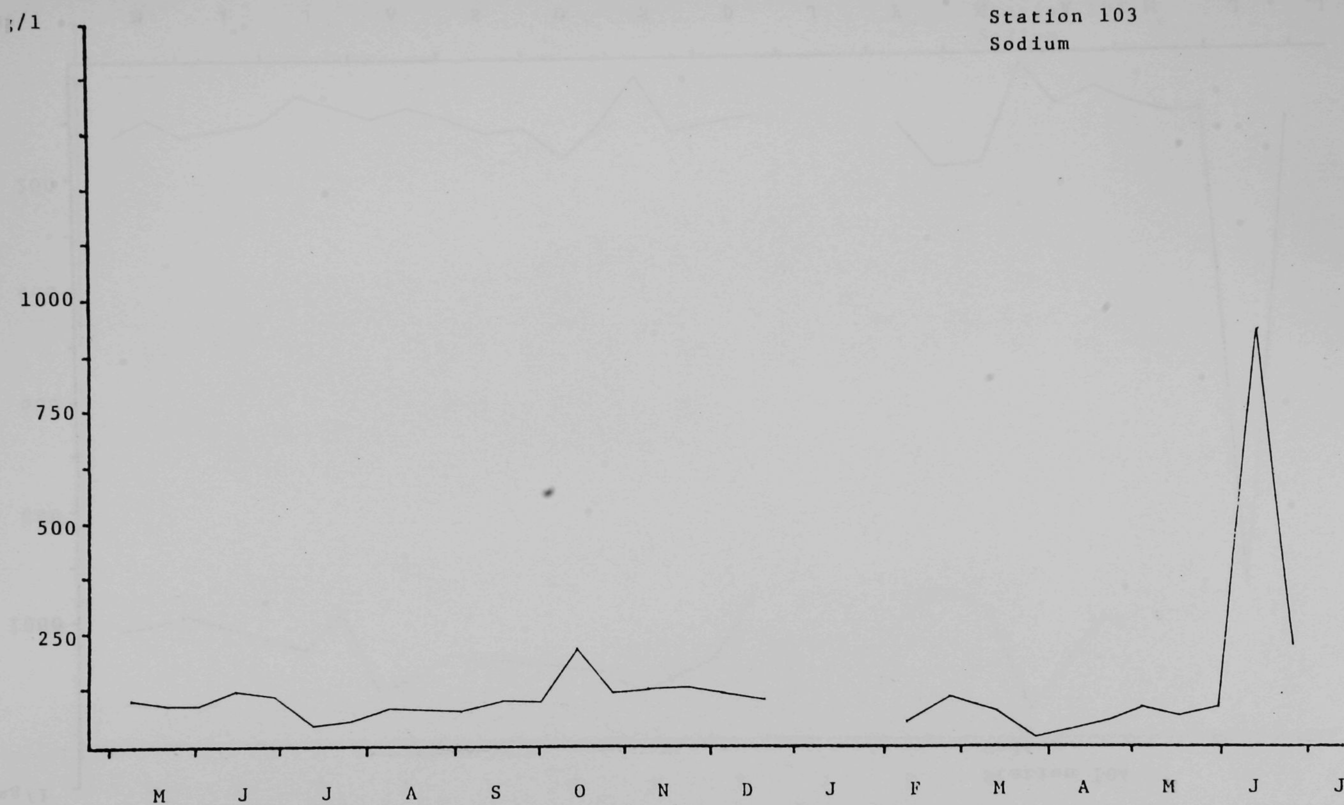


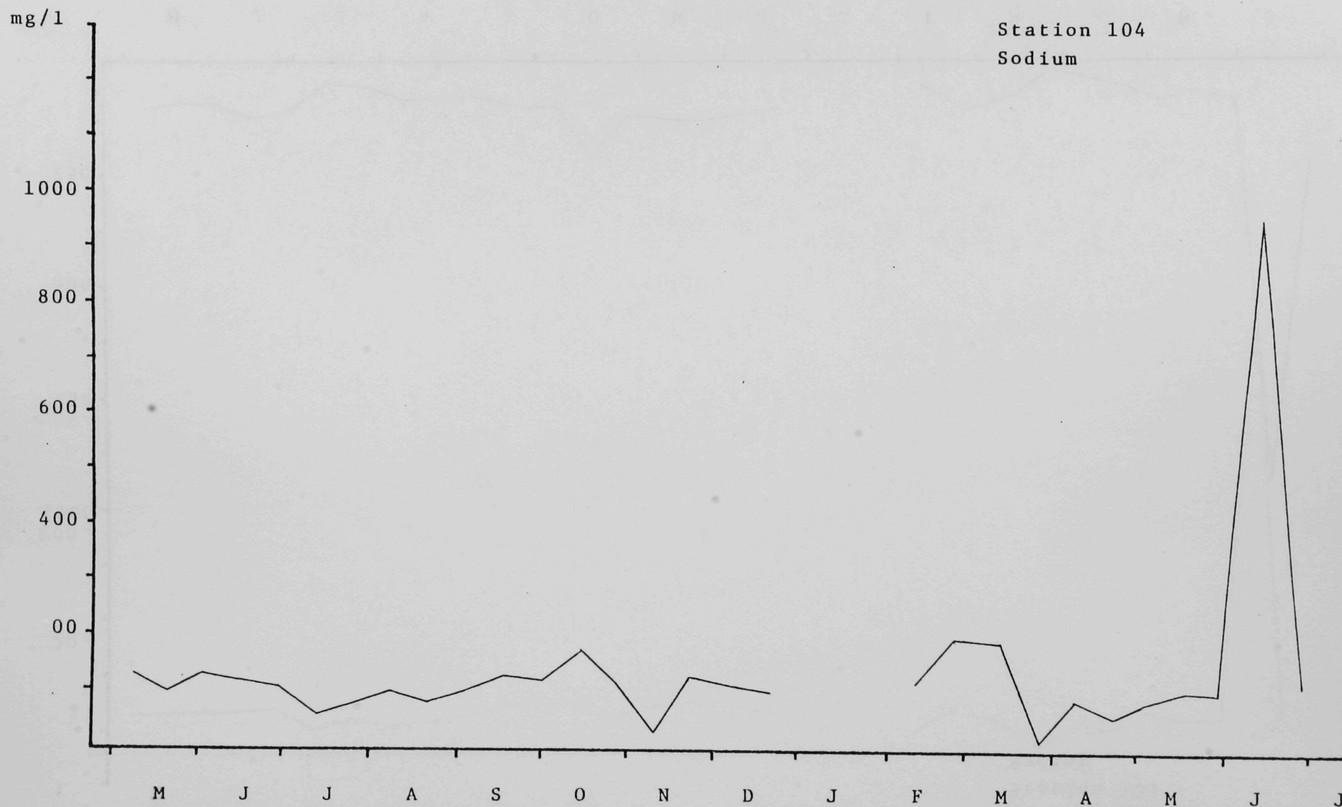
mg/l
Station 108
Calcium
640
480
320
160
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

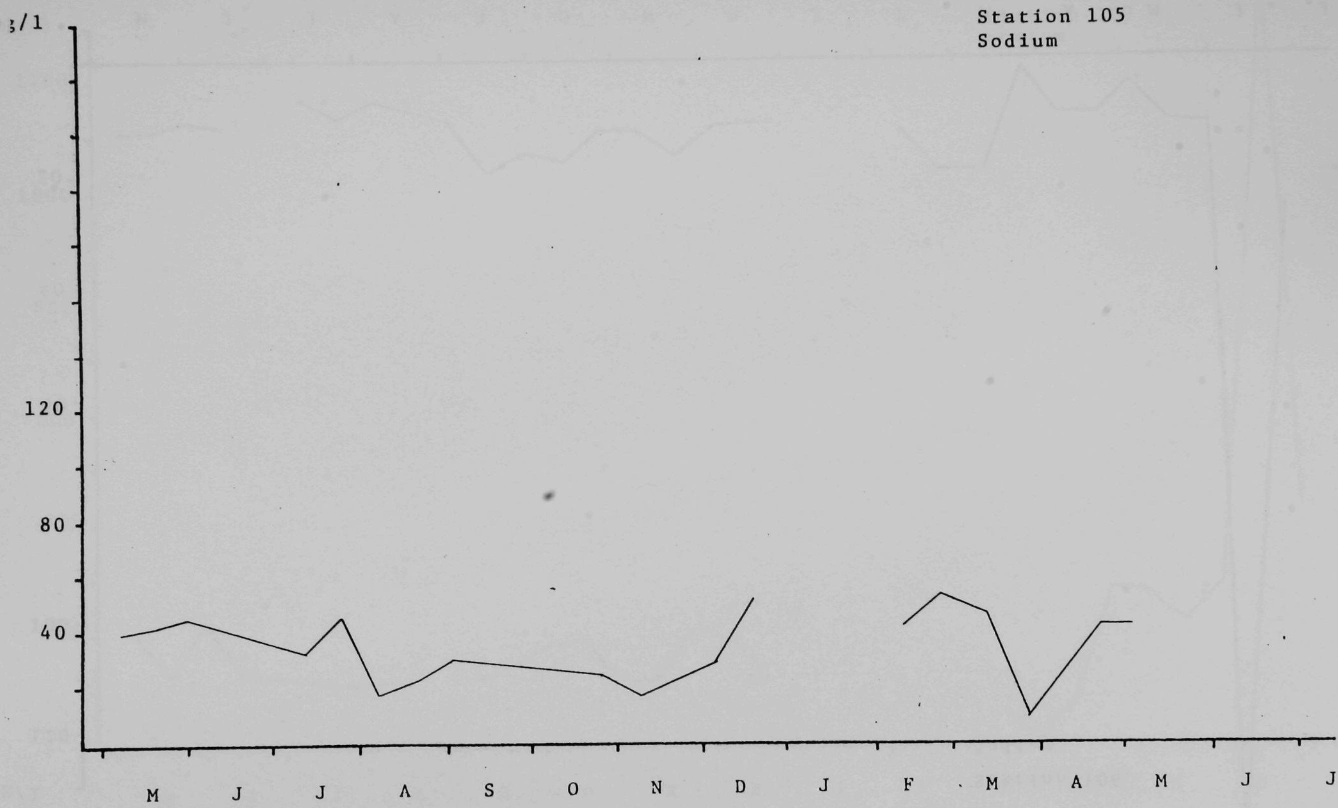


Station 101
Sodium
g/1
1000
800
600
400
200
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

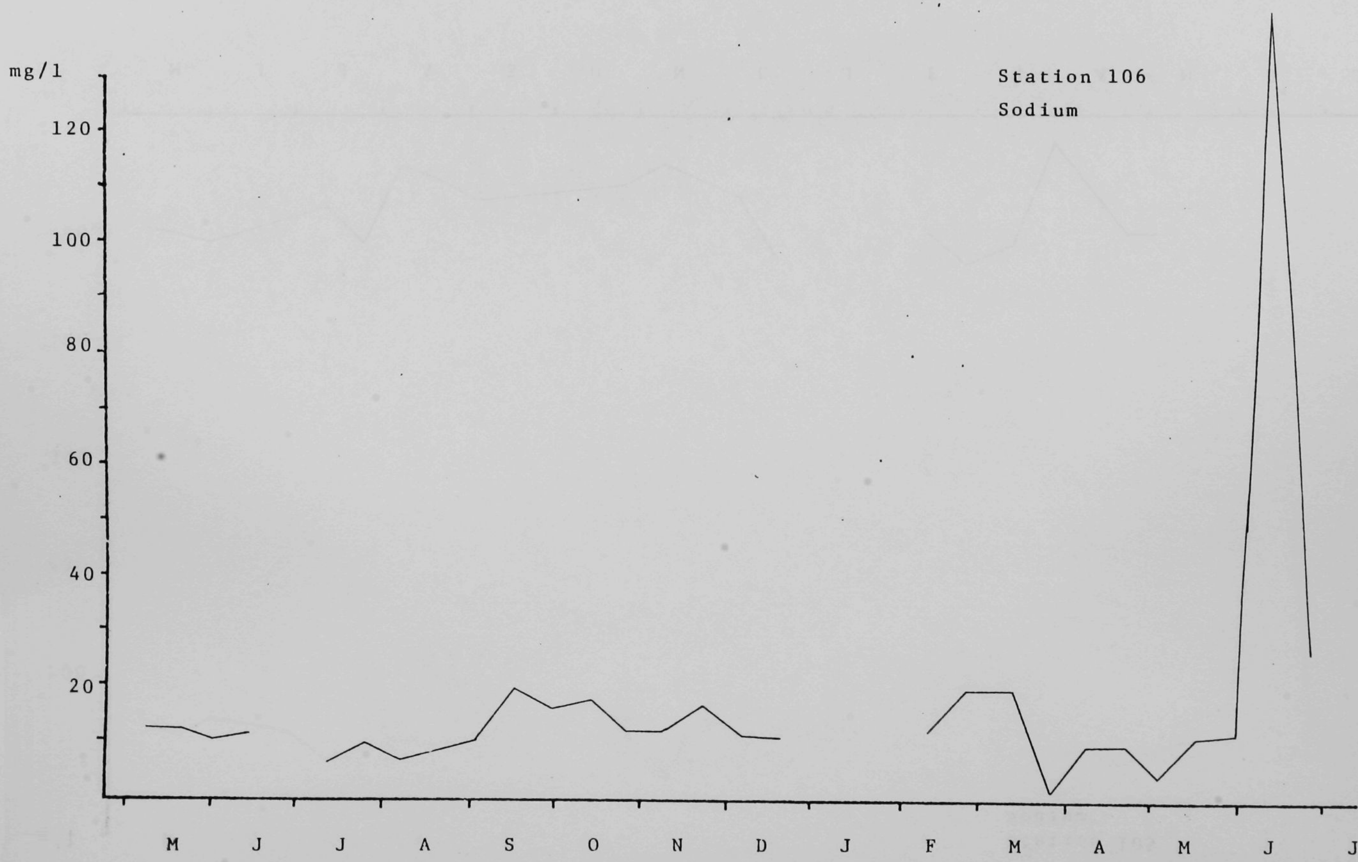

Station 102
Sodium
mg/1
1000
750
500
50
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 103
Sodium
;/1
1000
750
500
250
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

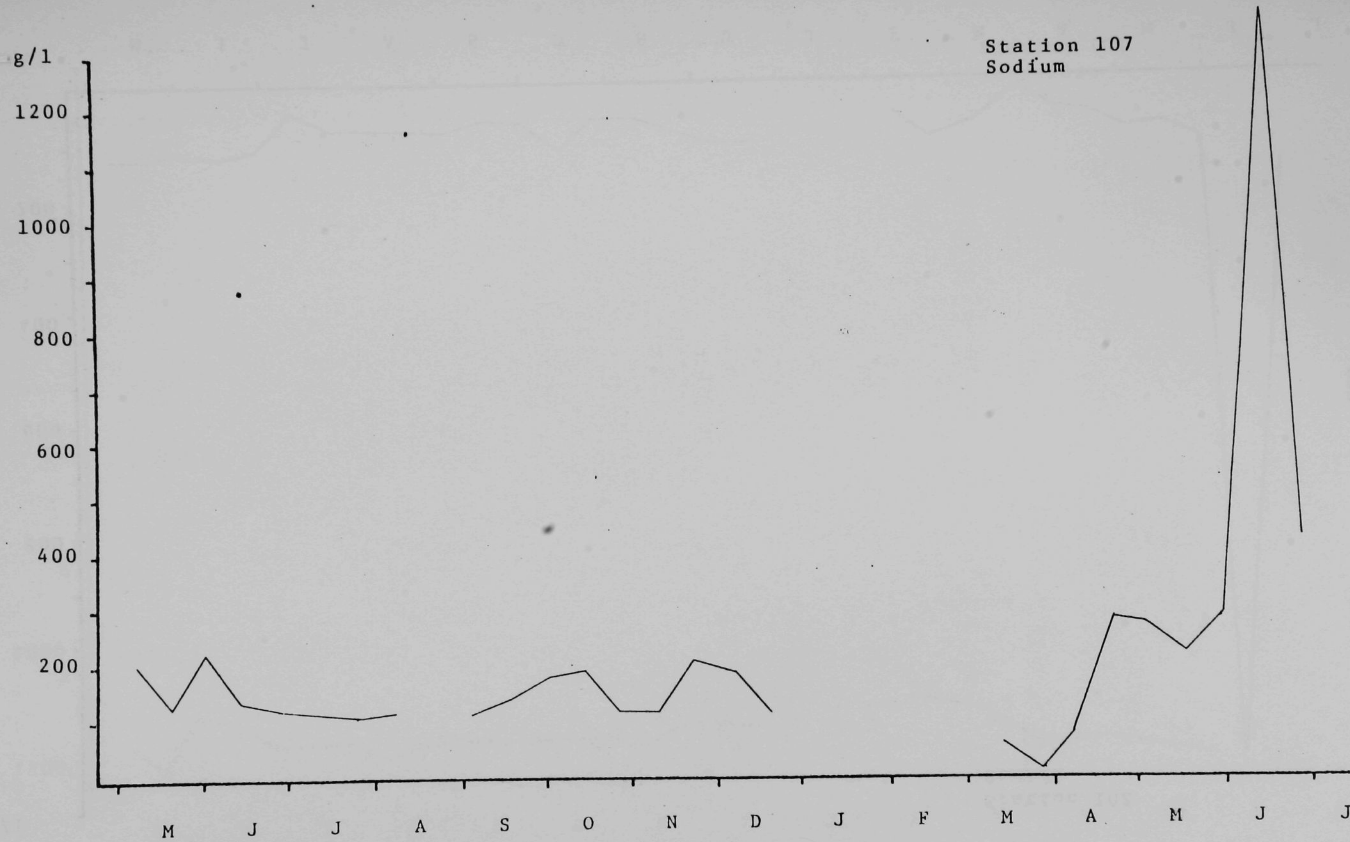

Station 104
Sodium
mg/1
1000
800
600
400
00
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

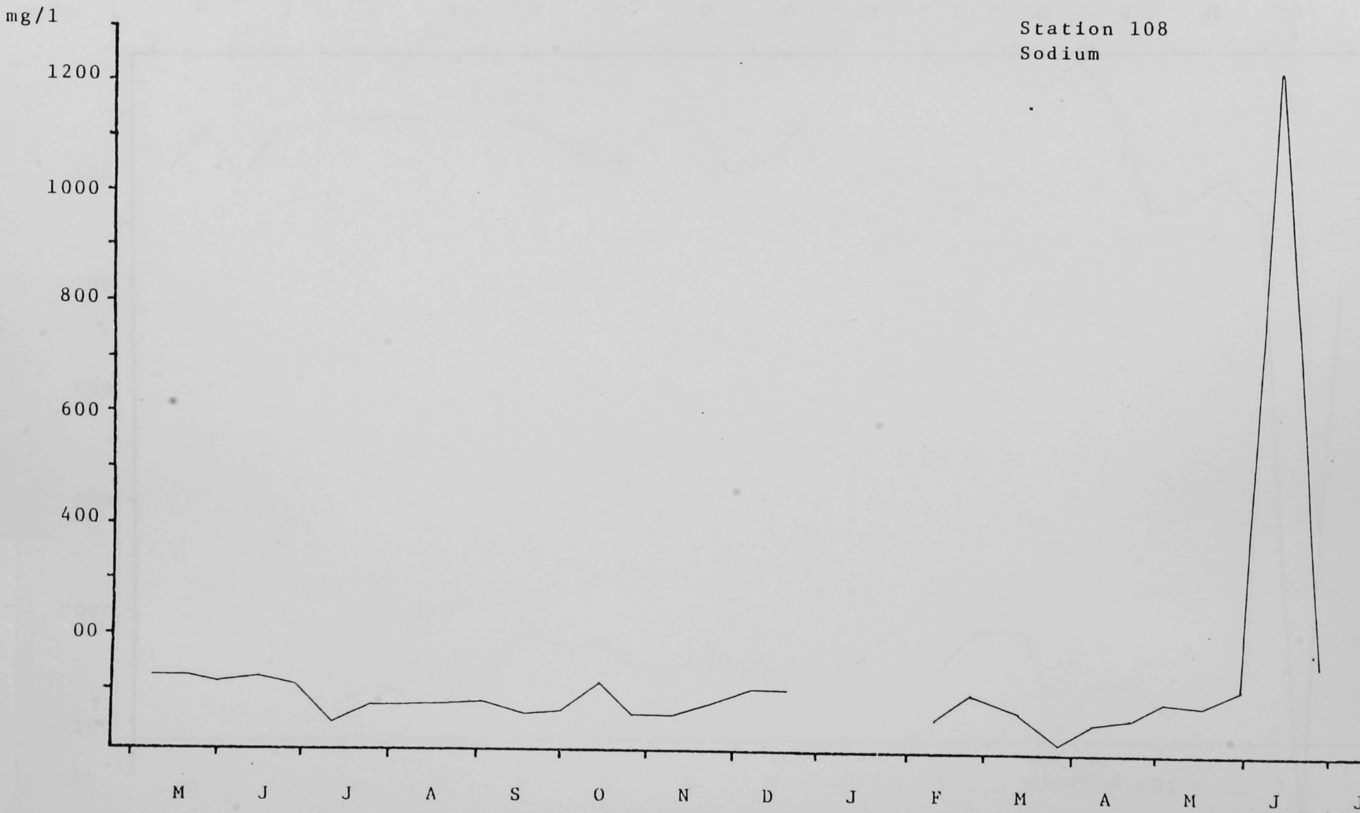


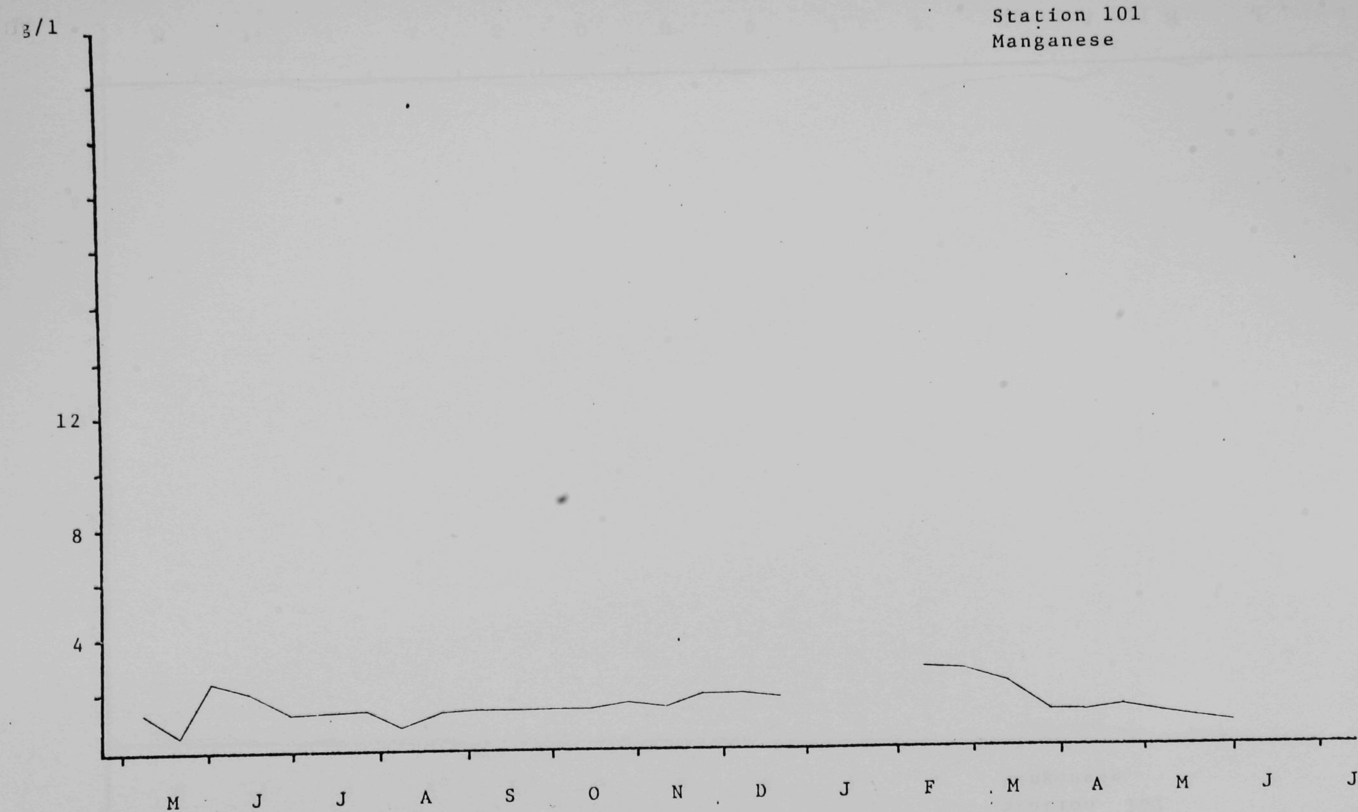
g/1
Station 105
Sodium
120
80
40
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

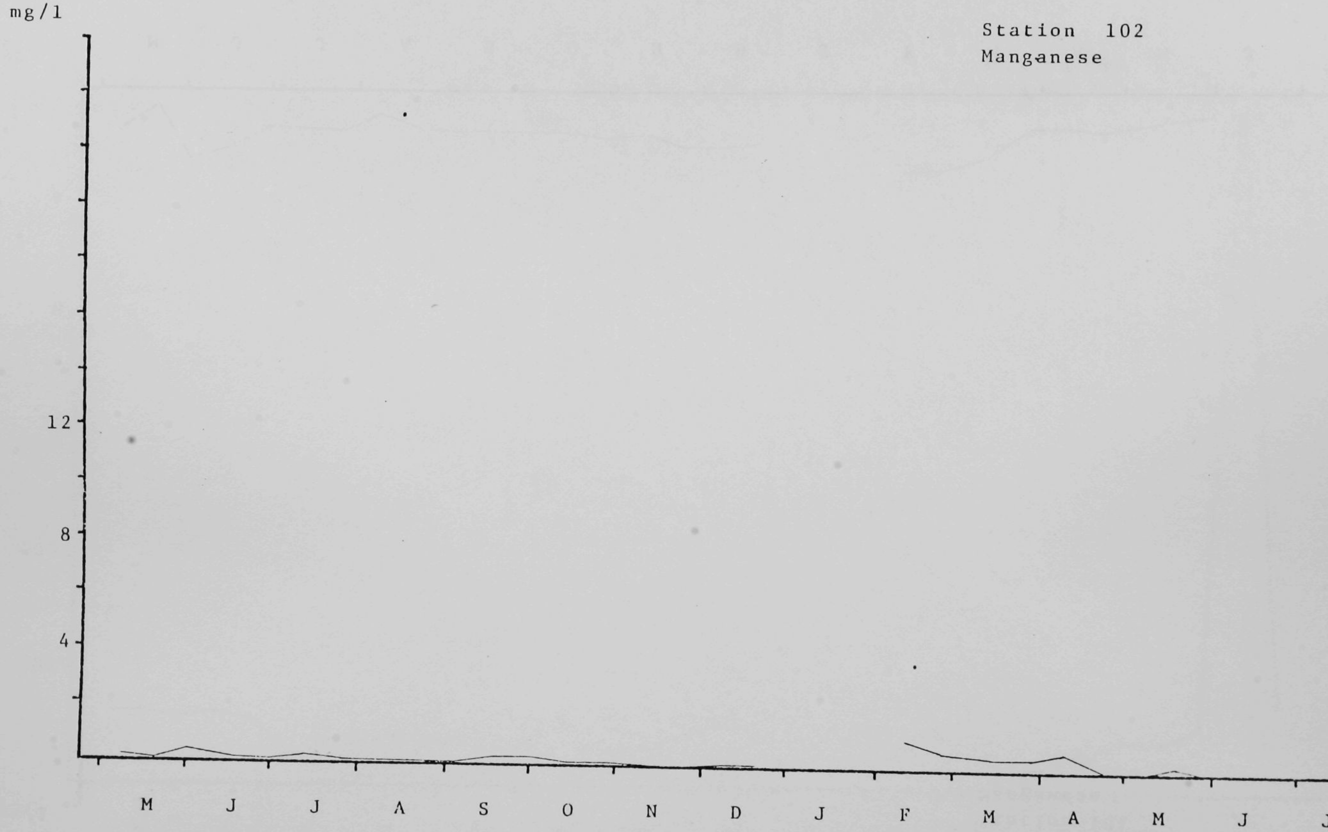


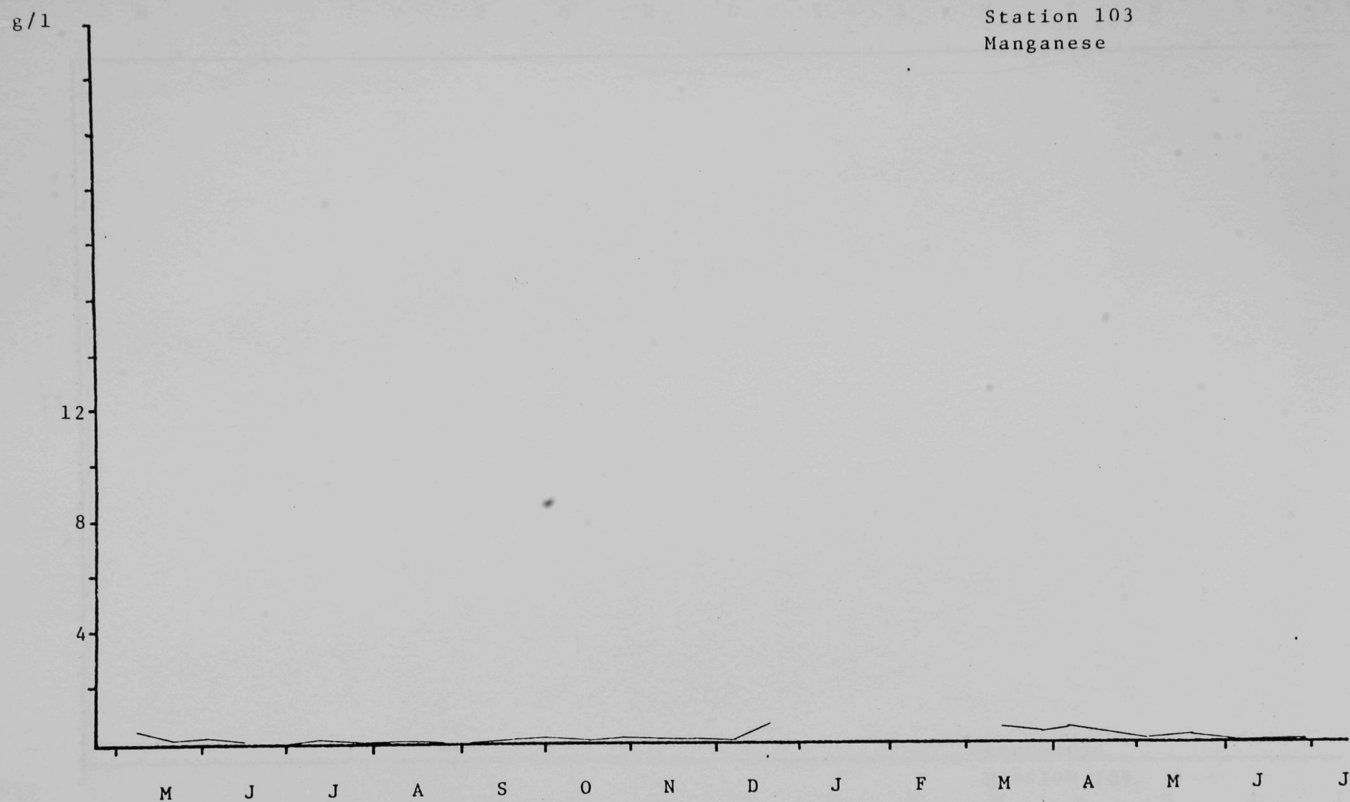
mg/l
Station 106
Sodium
120
100
80
60
40
20
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 107
Sodium
g/1
1200
1000
800
600
400
200
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

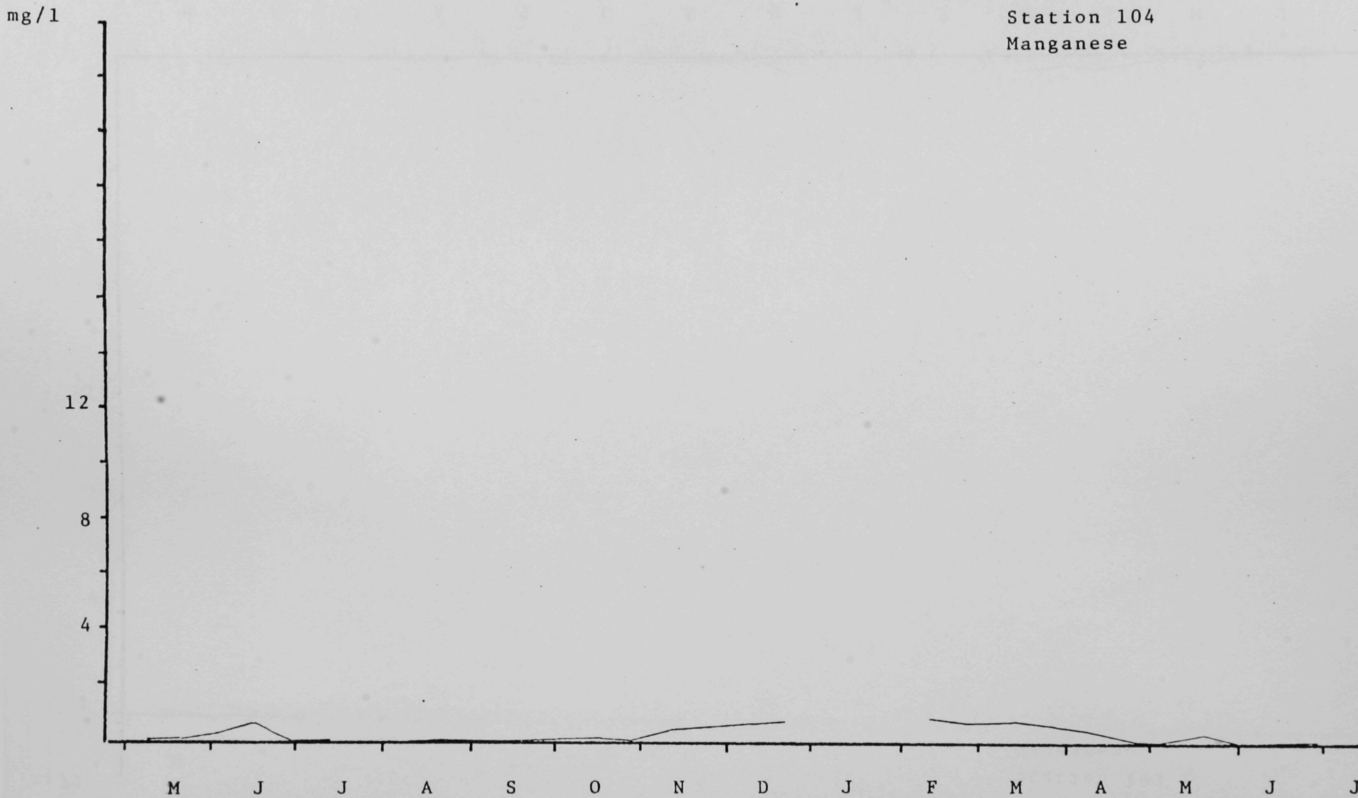

mg/1
1200
1000
800
600
400
00
Station 108
Sodium
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

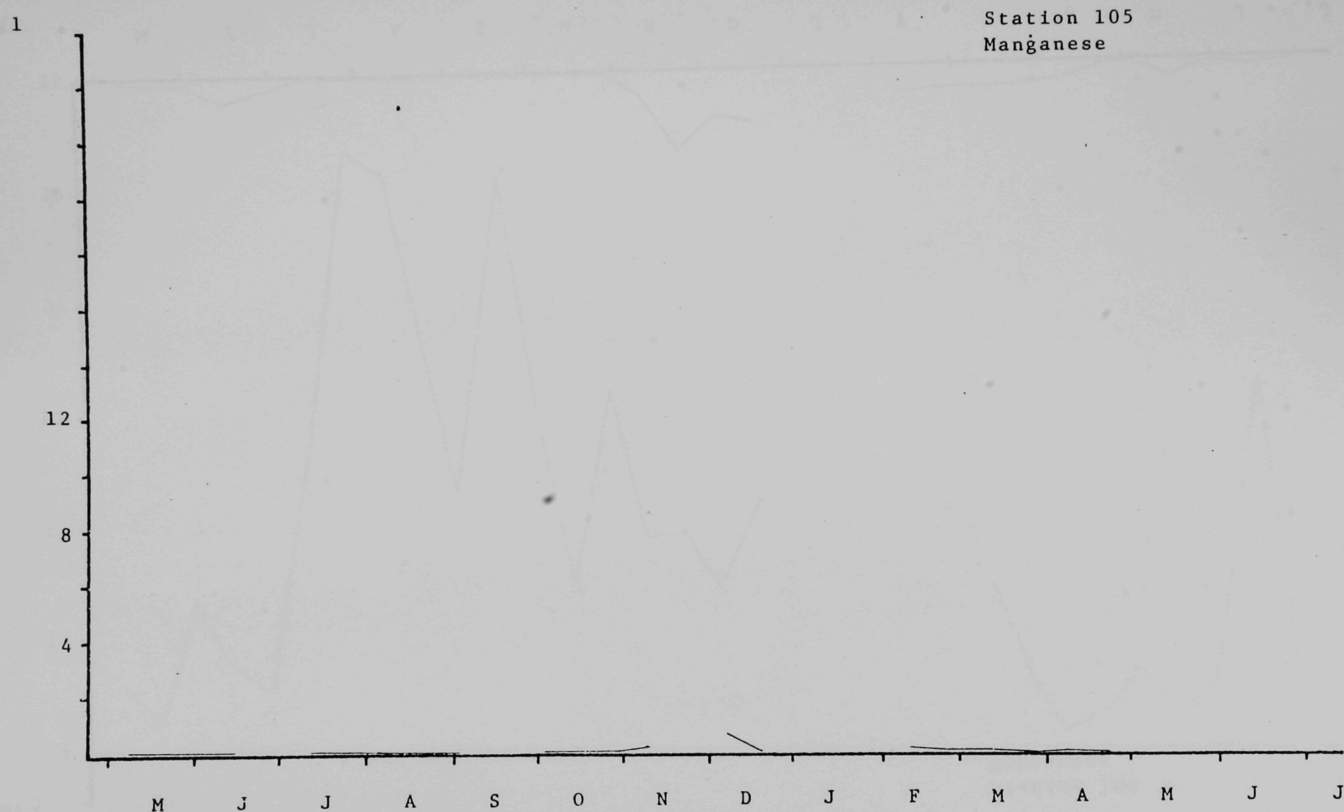

Station 101
Manganese
g/l
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

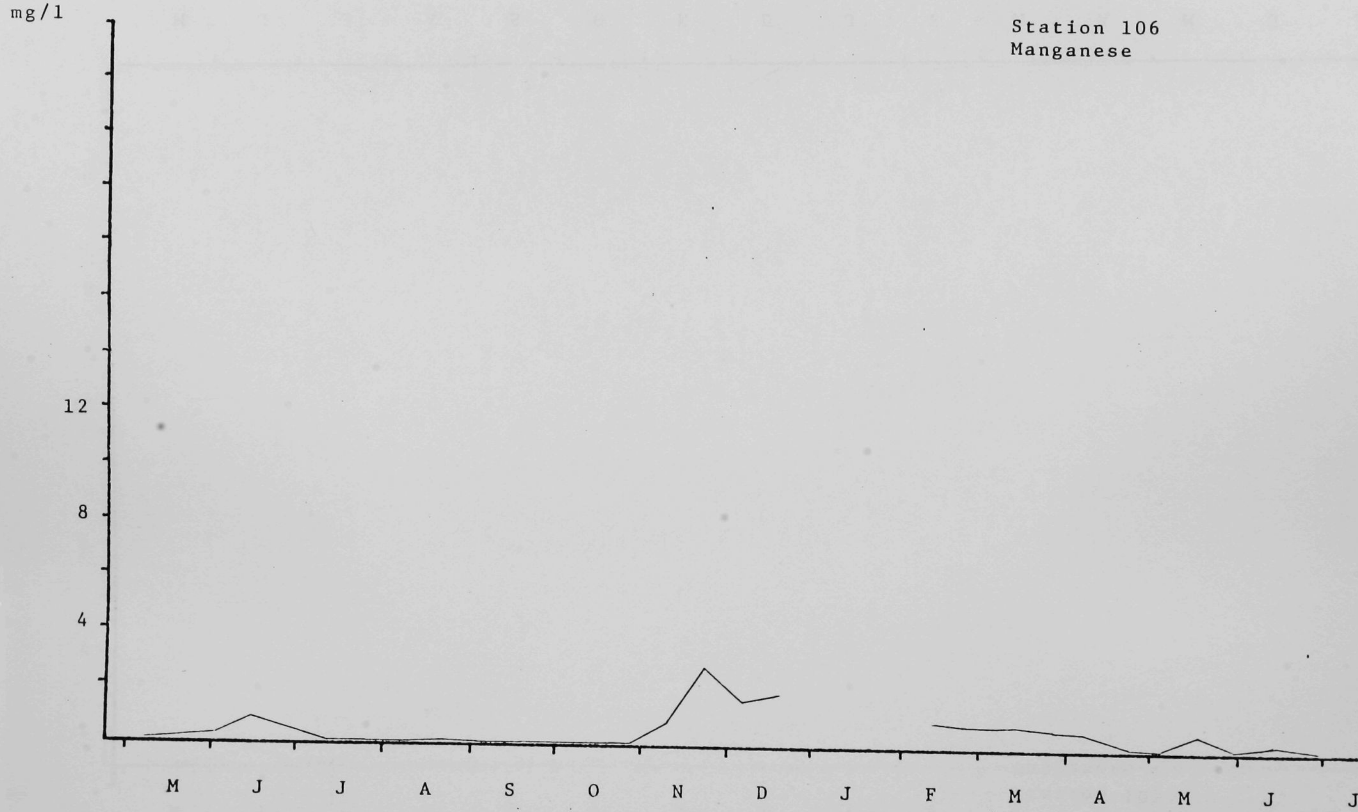

mg/l
Station 102
Manganese
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

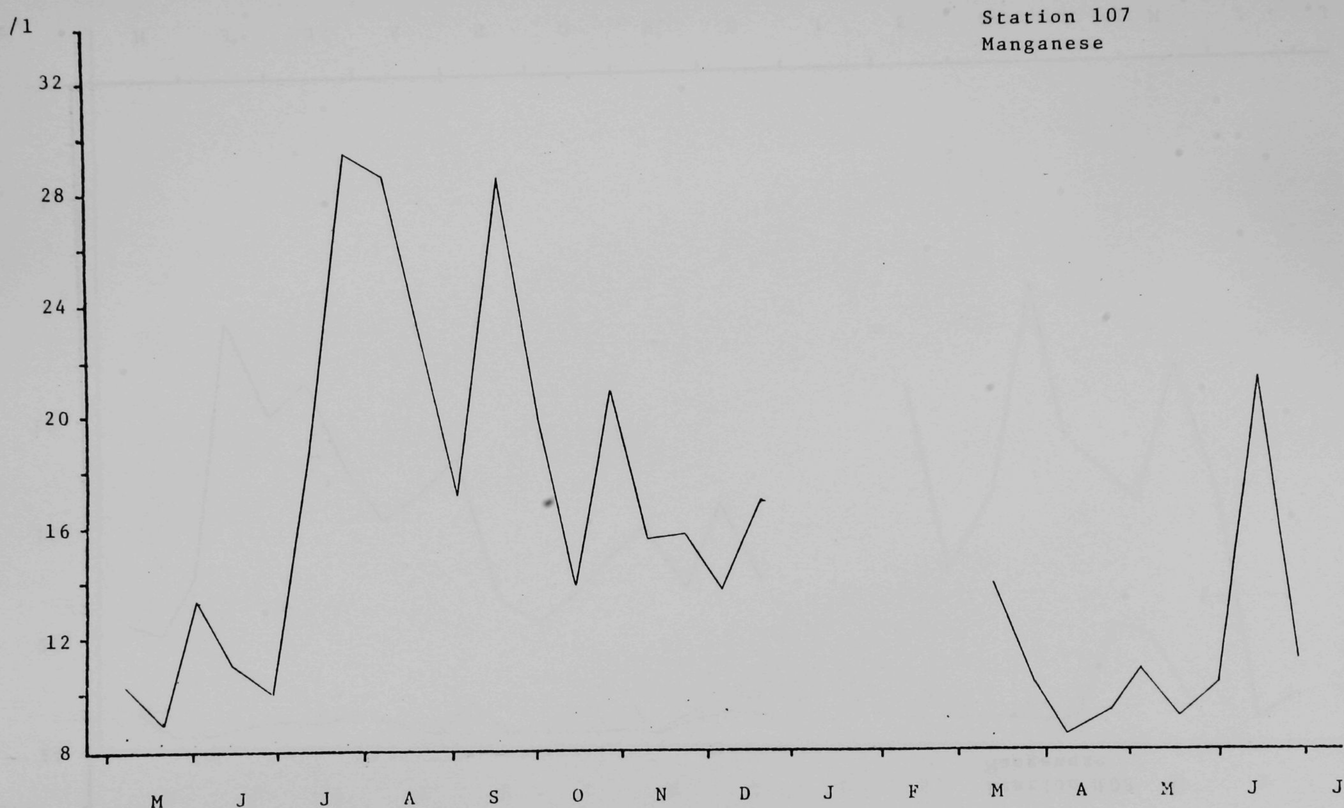


203

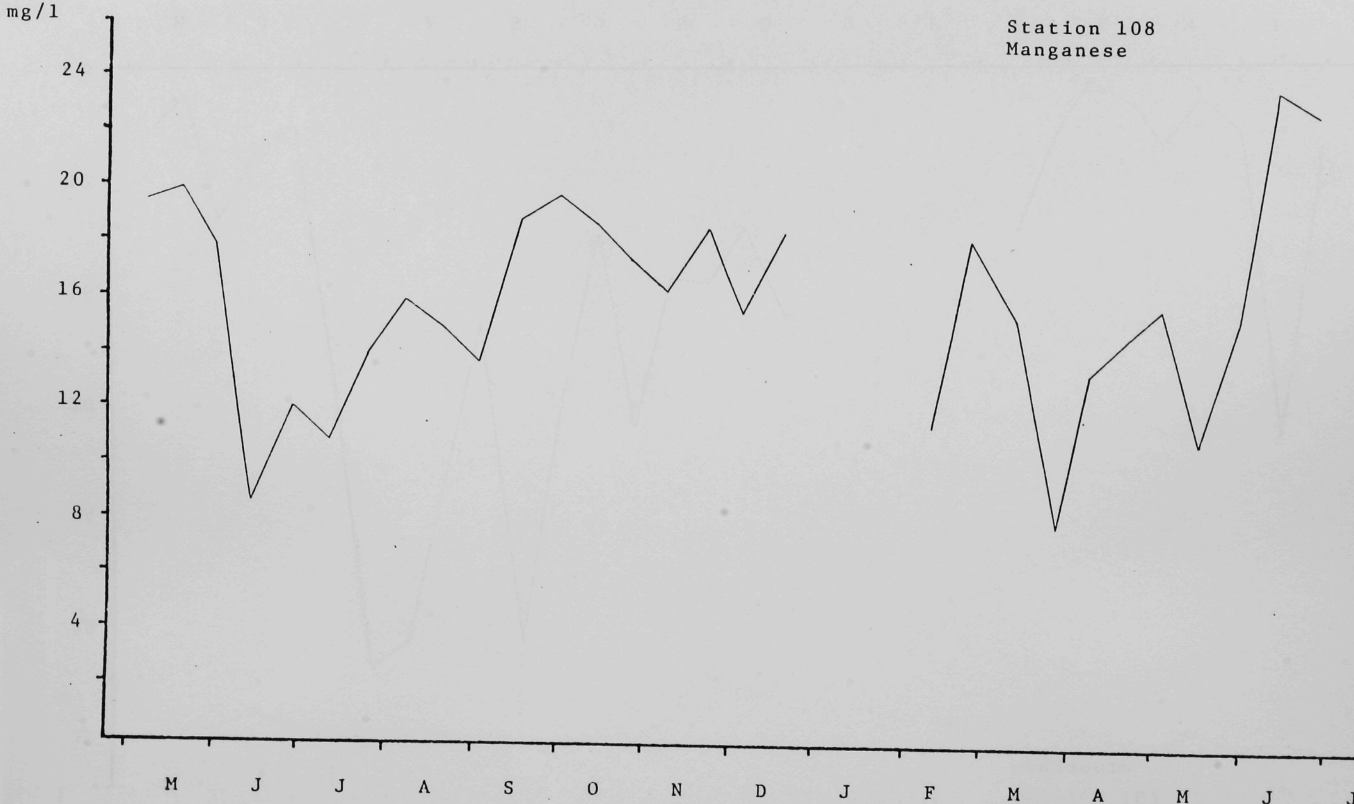

Station 104
Manganese
mg/l
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

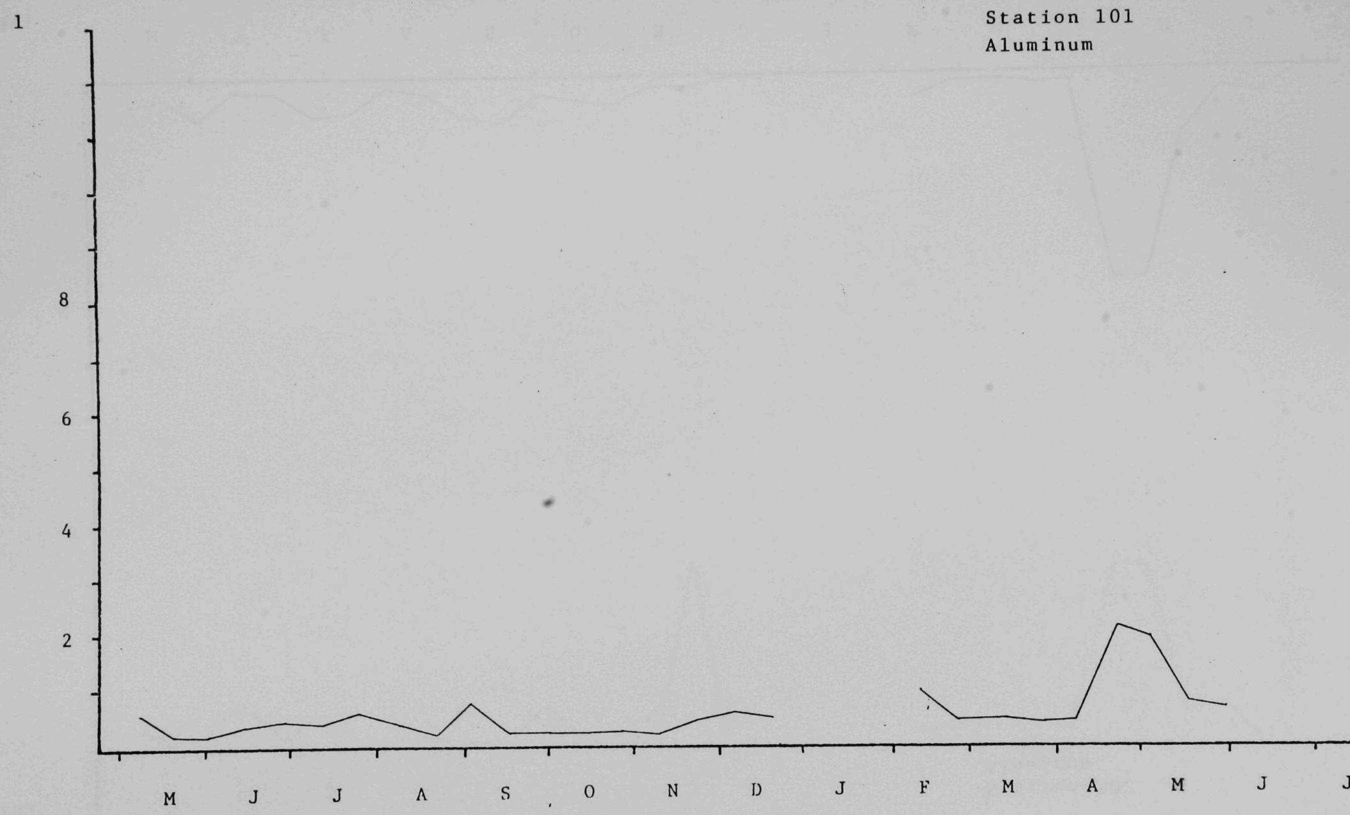

Station 105
Manganese
1
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

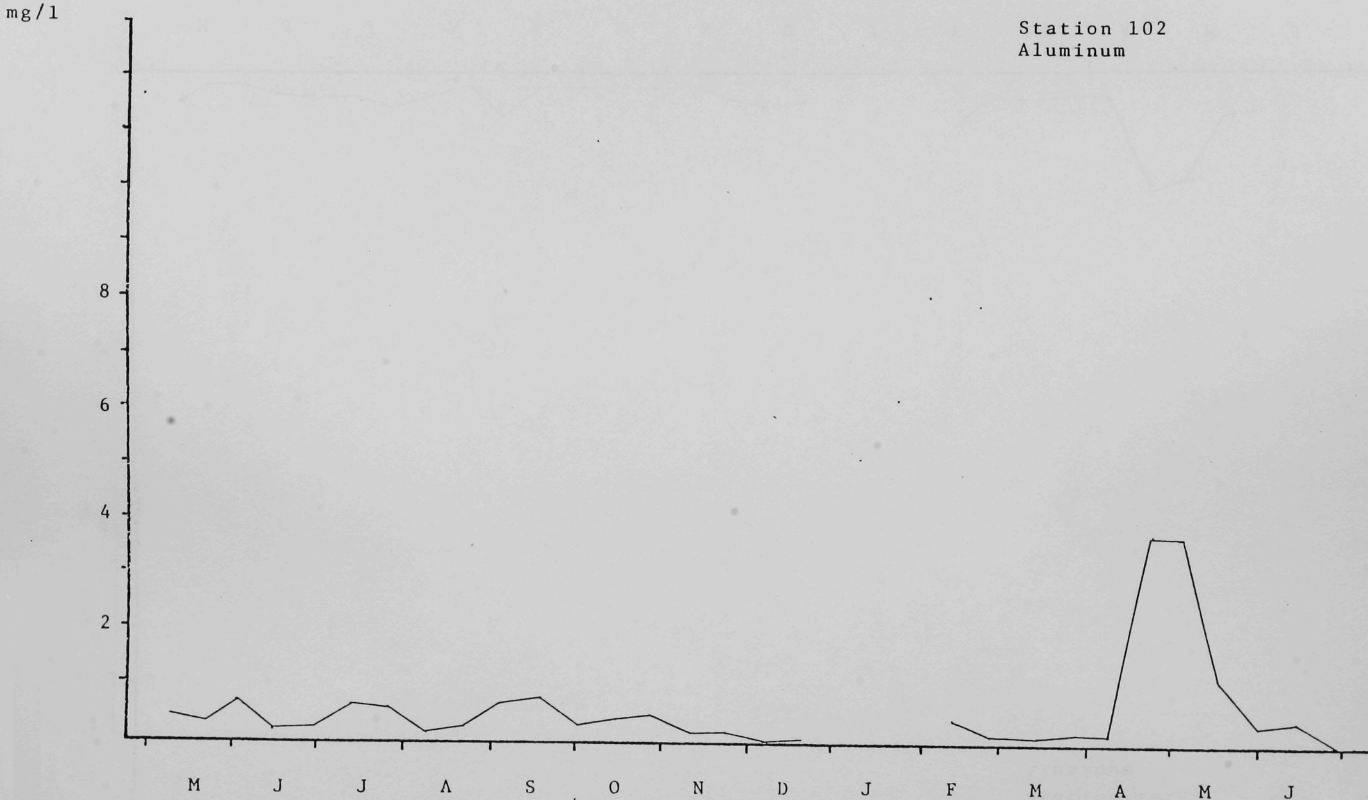

mg/l
Station 106
Manganese
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

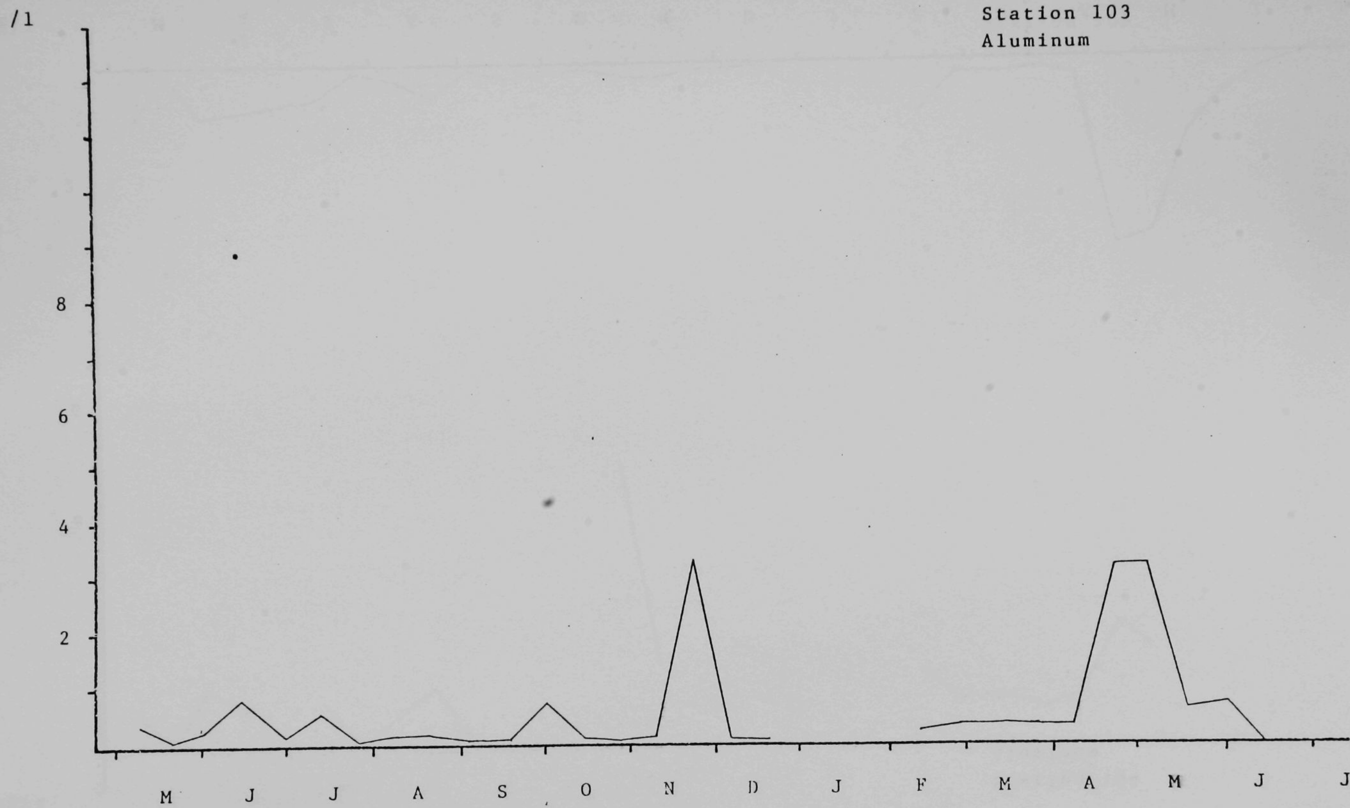


Station 107
Manganese
/1
32
28
24
20
16
12
8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

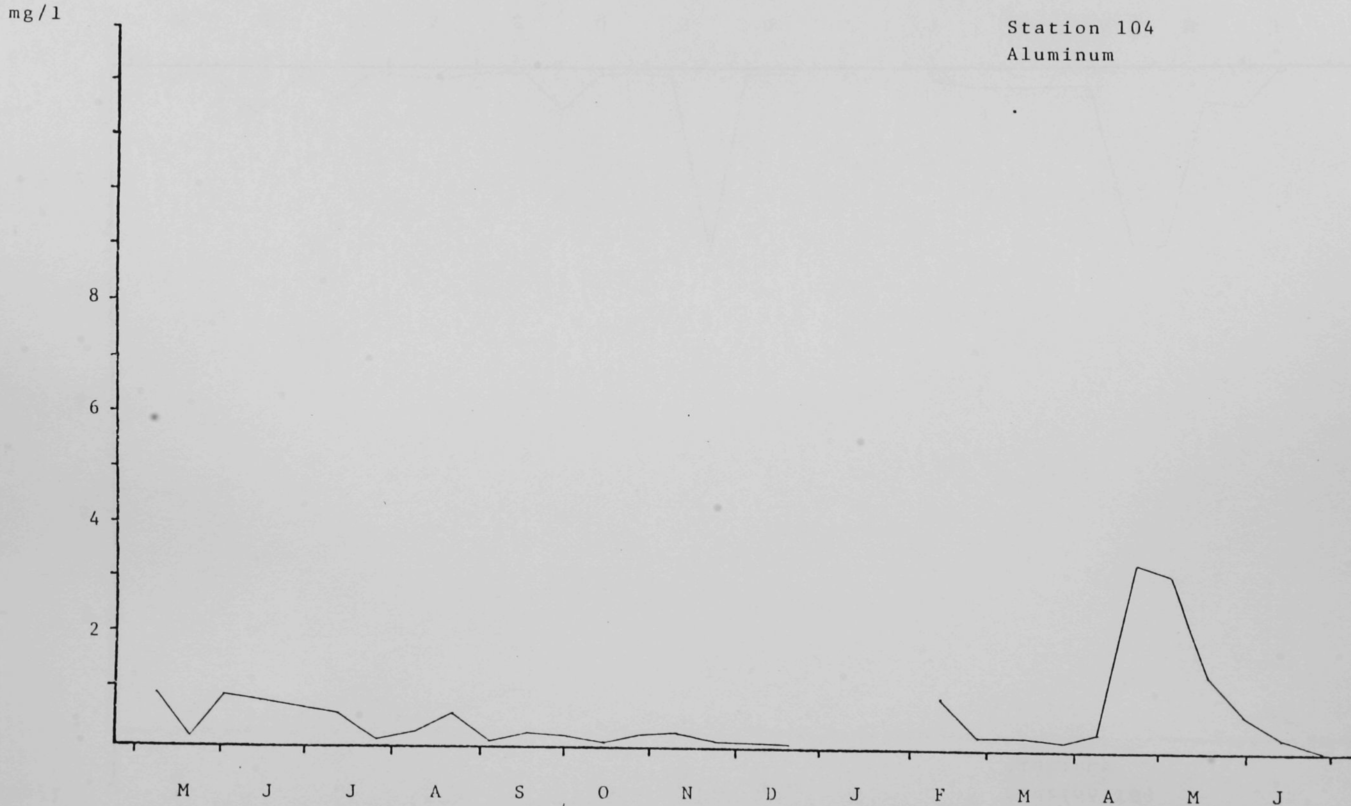

mg/1
24
20
16
12
8
4
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
Station 108
Manganese


Station 101
Aluminum
1
8
6
4
2
M J J A S O N D J F M A M J J

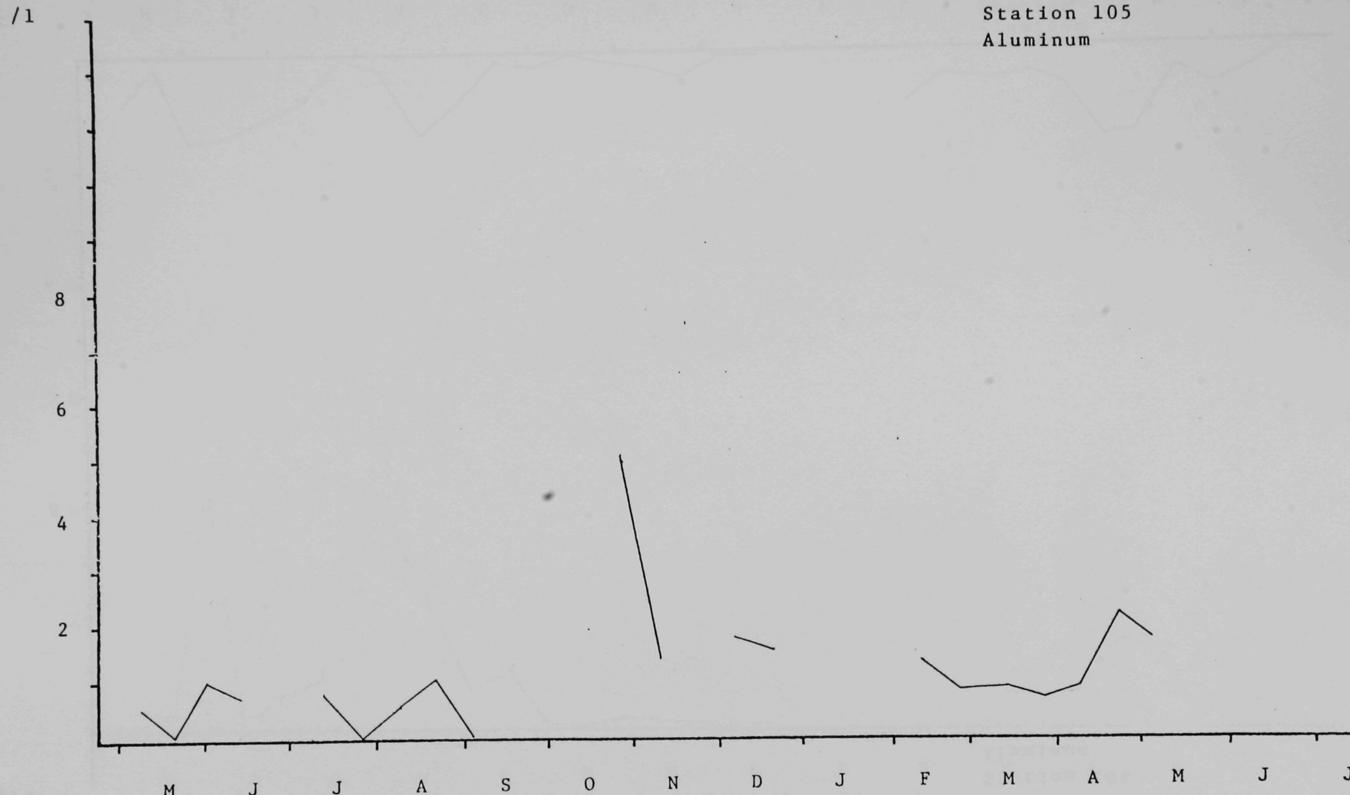

mg/l
Station 102
Aluminum
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J



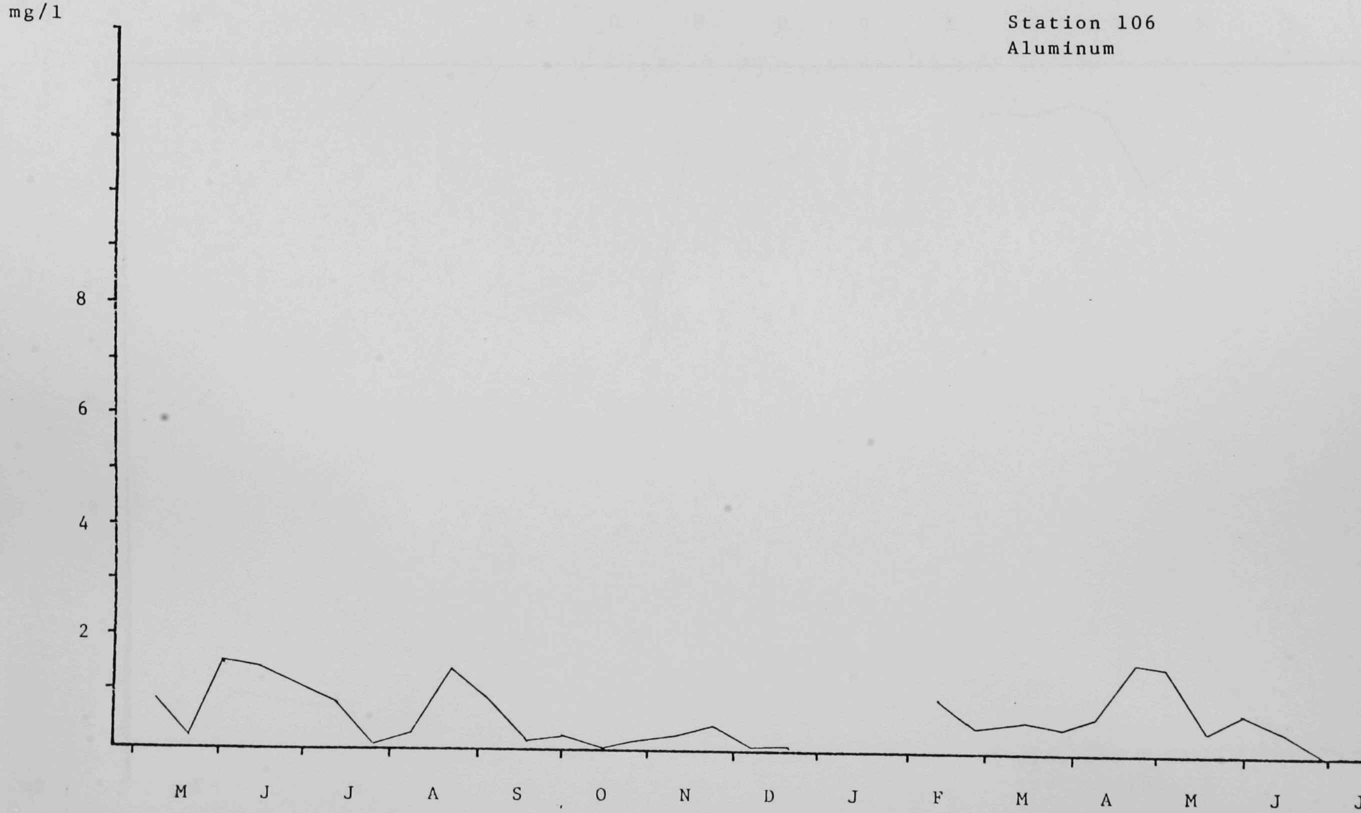
/1
Station 103
Aluminum
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

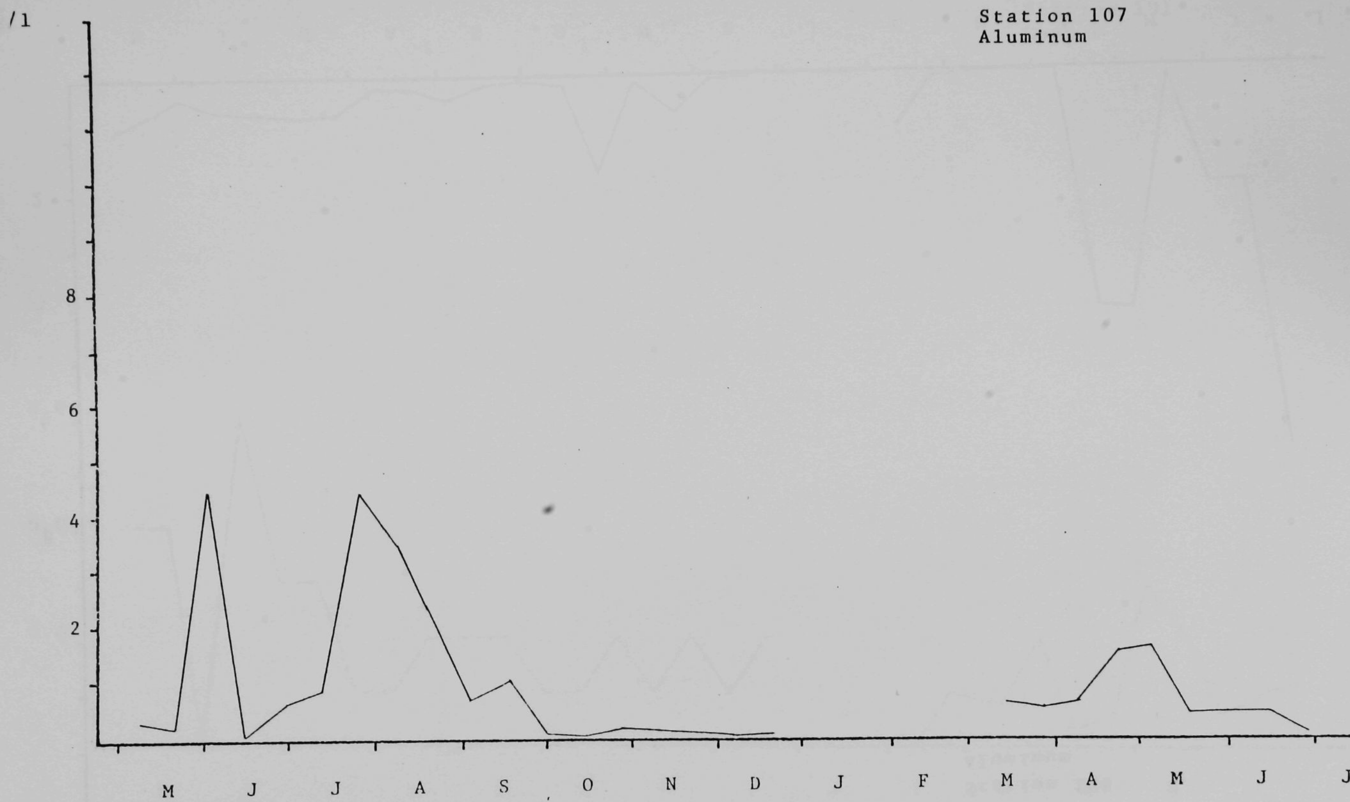


mg/l
Station 104
Aluminum
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J

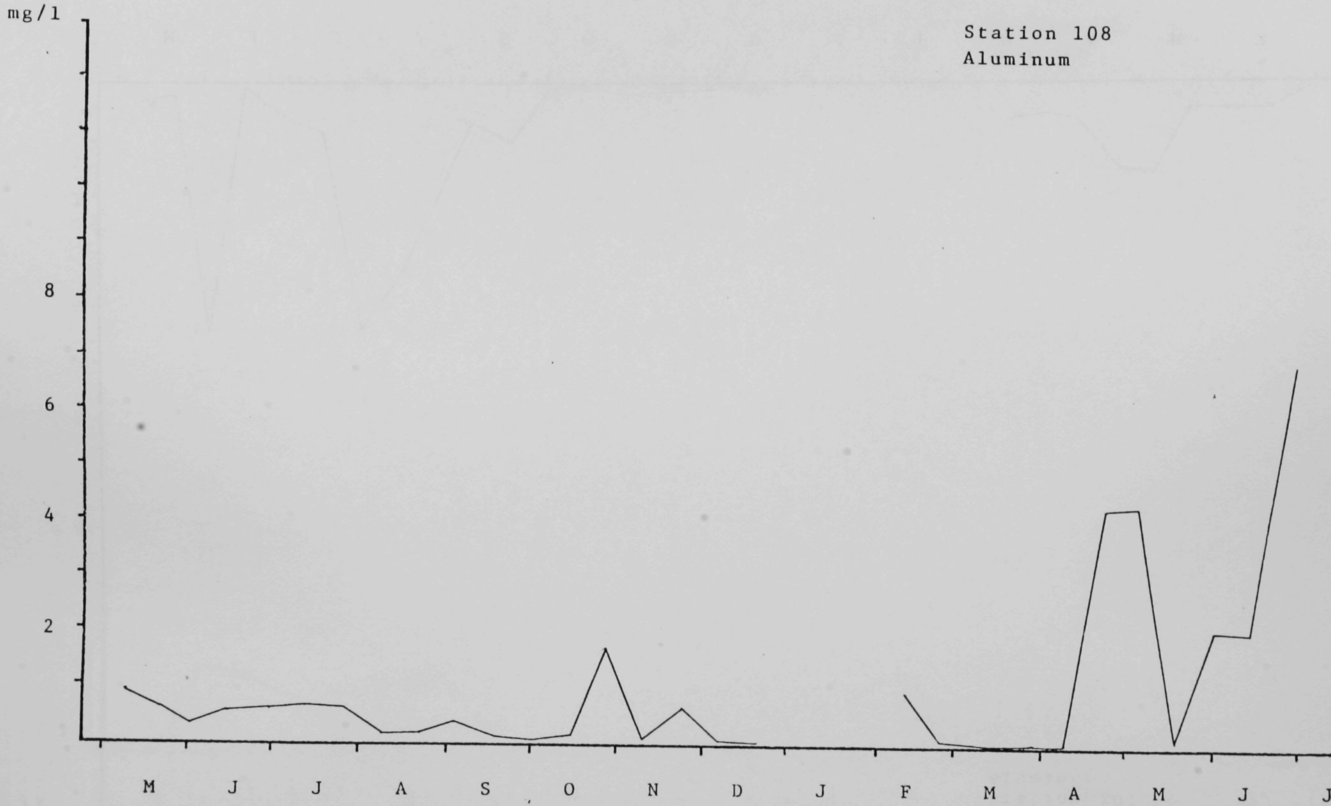


/1
Station 105
Aluminum
8
6
4
2
M J J A S O N D J F M A M J J


mg/l
Station 106
Aluminum
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



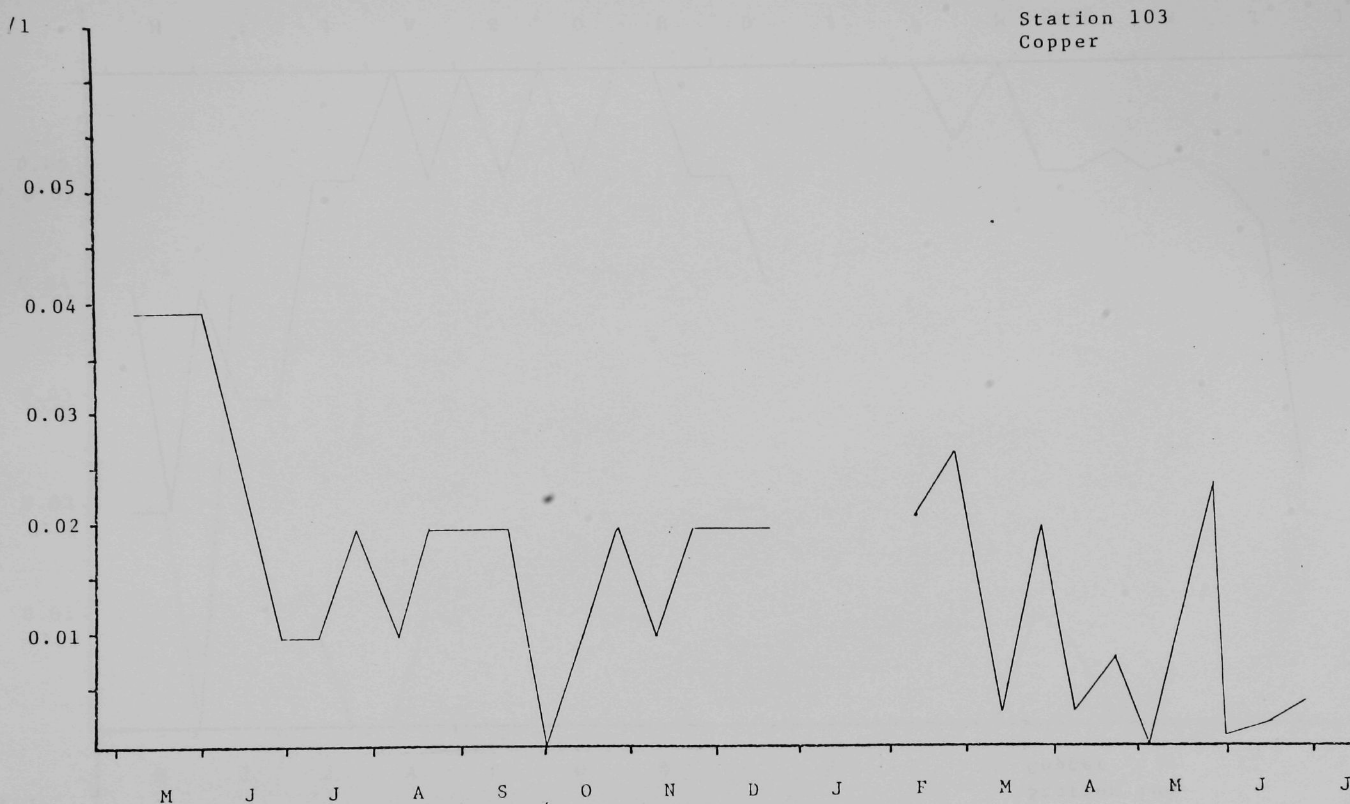
/1
Station 107
Aluminum
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

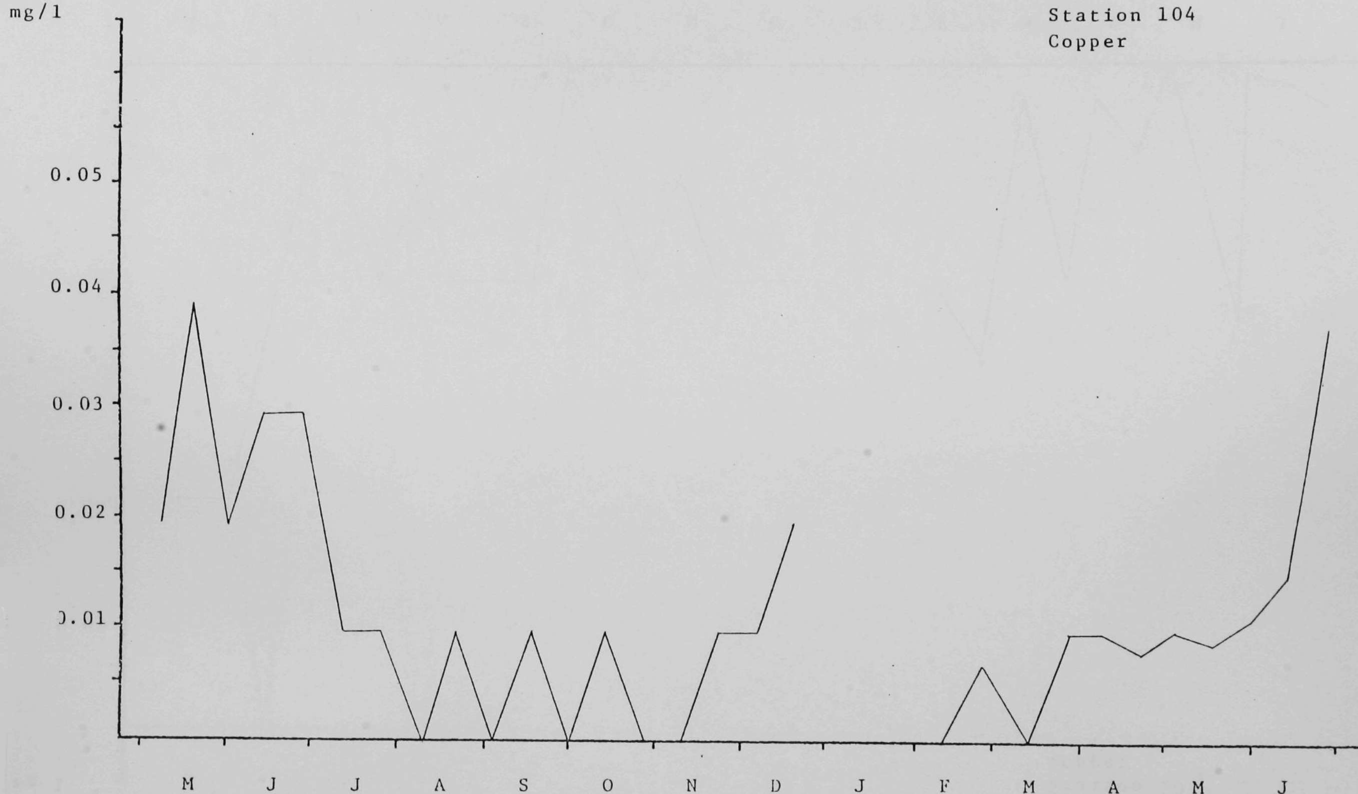


mg/1
Station 108
Aluminum
8
6
4
2
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


/1
Station 101
Copper
0.08
0.06
0.04
0.02
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

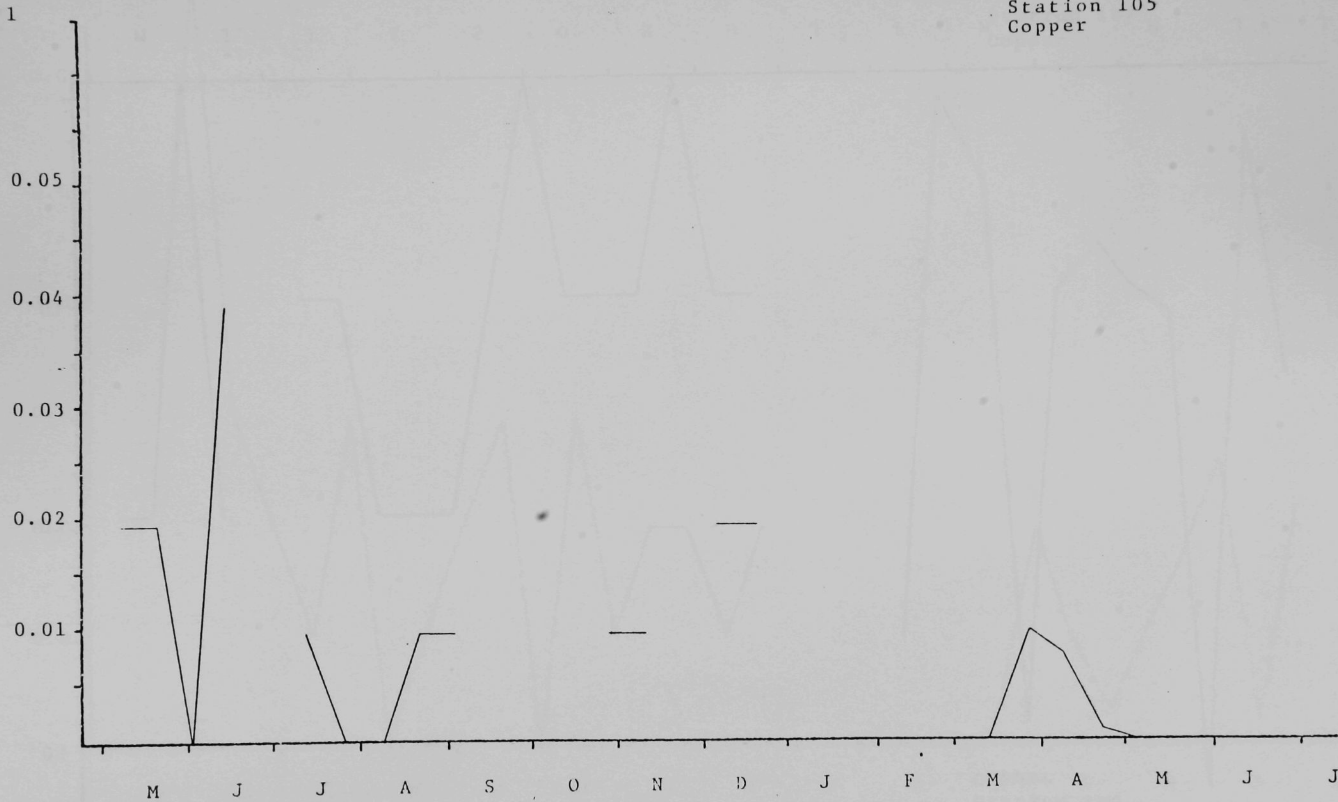
mg/1
Station 102
Copper
0.05
0.04
0.03
0.02
0.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J

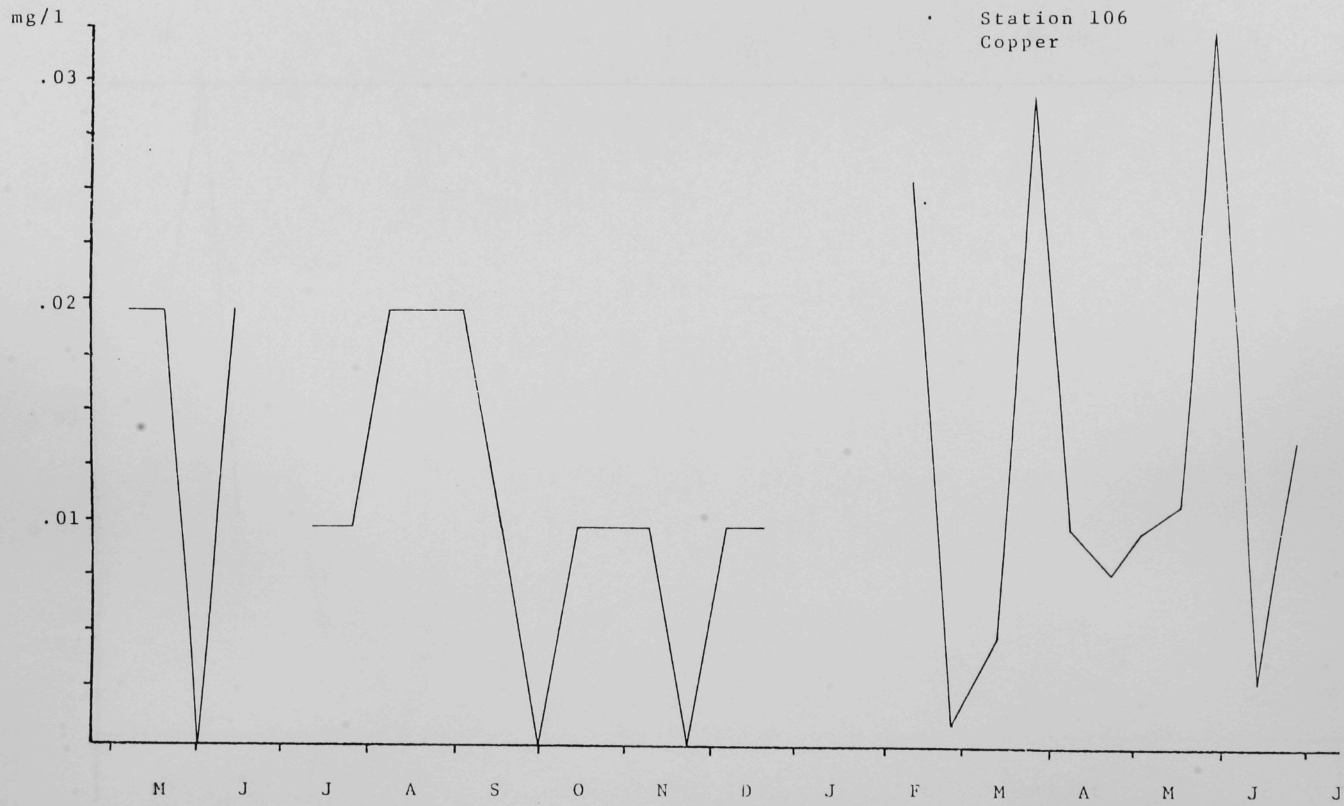

Station 103
Copper
/1
0.05
0.04
0.03
0.02
0.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

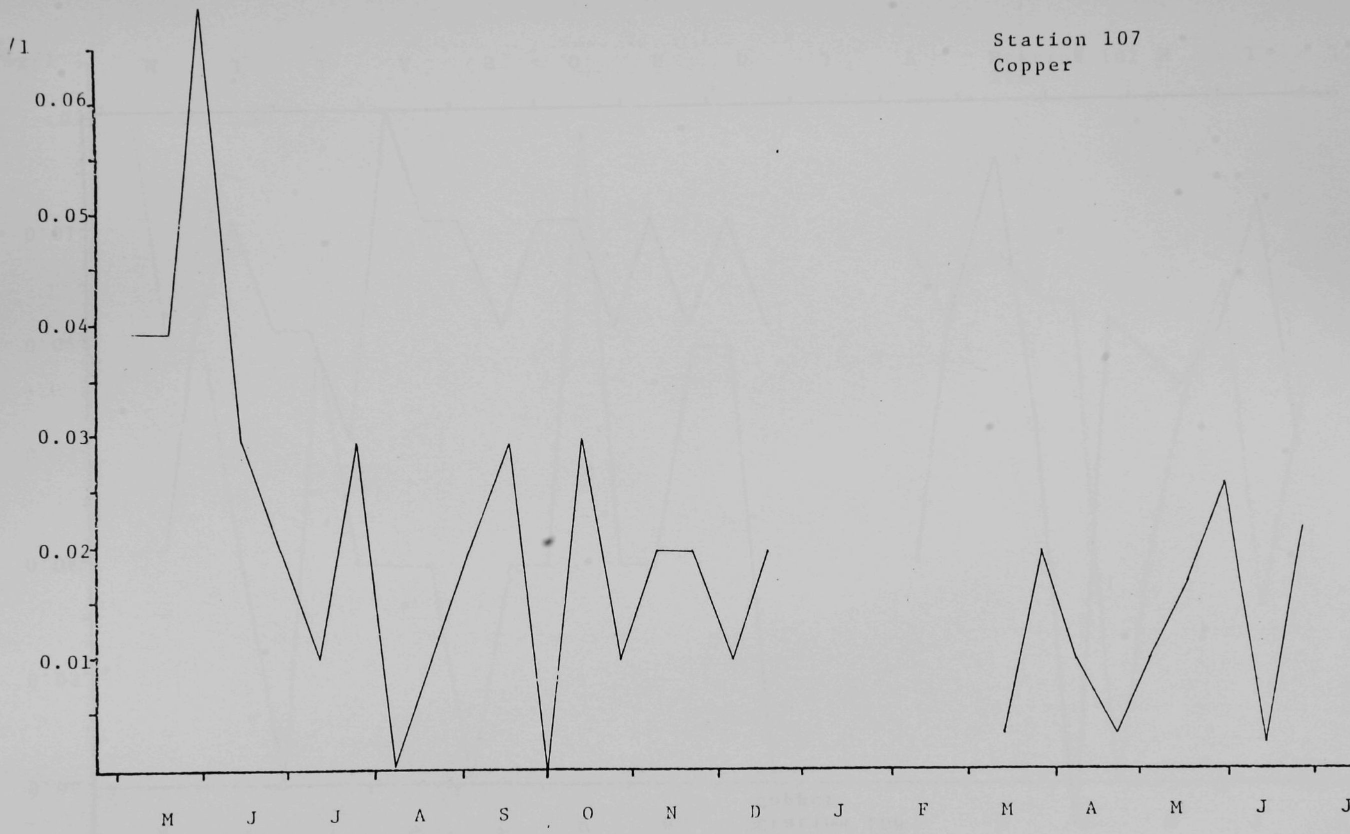


mg/l
Station 104
Copper
0.05
0.04
0.03
0.02
0.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J

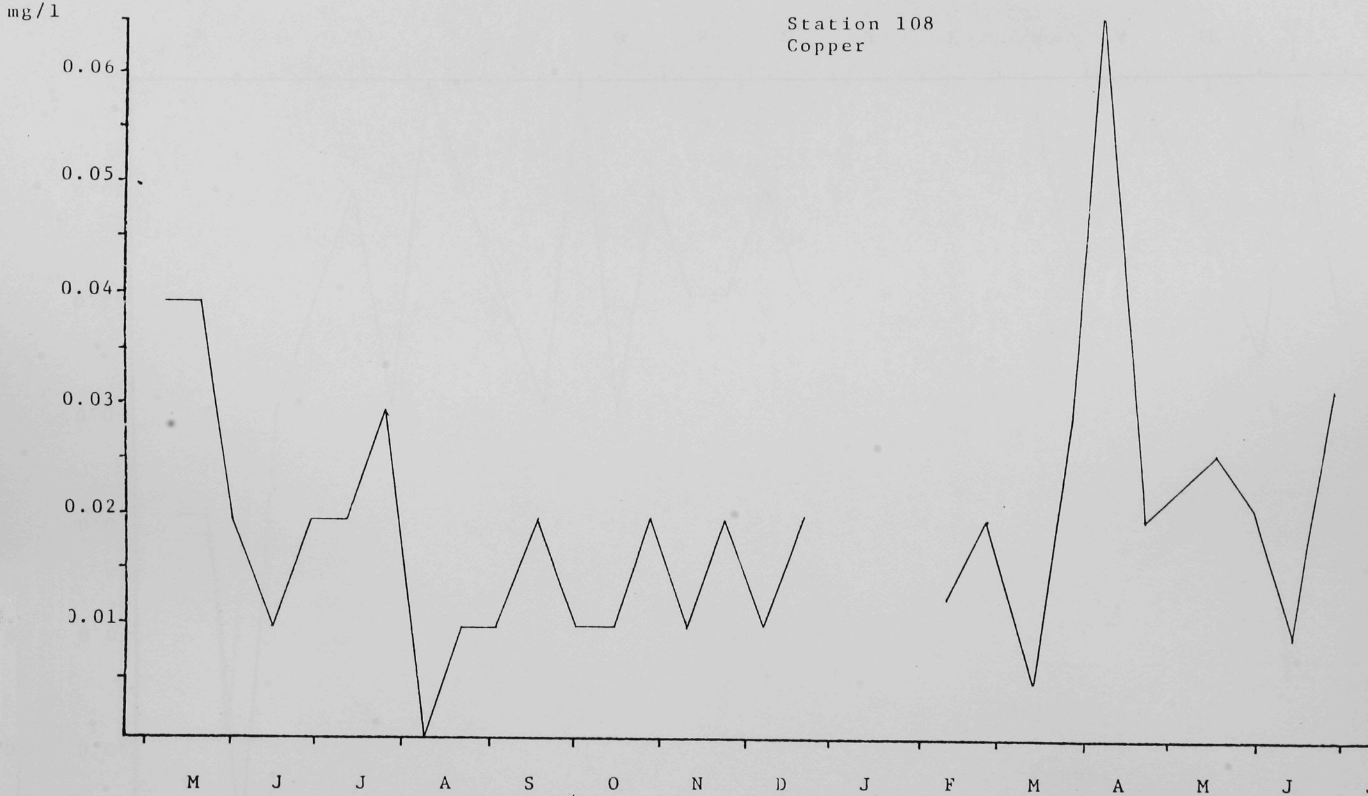
Station 105
Copper

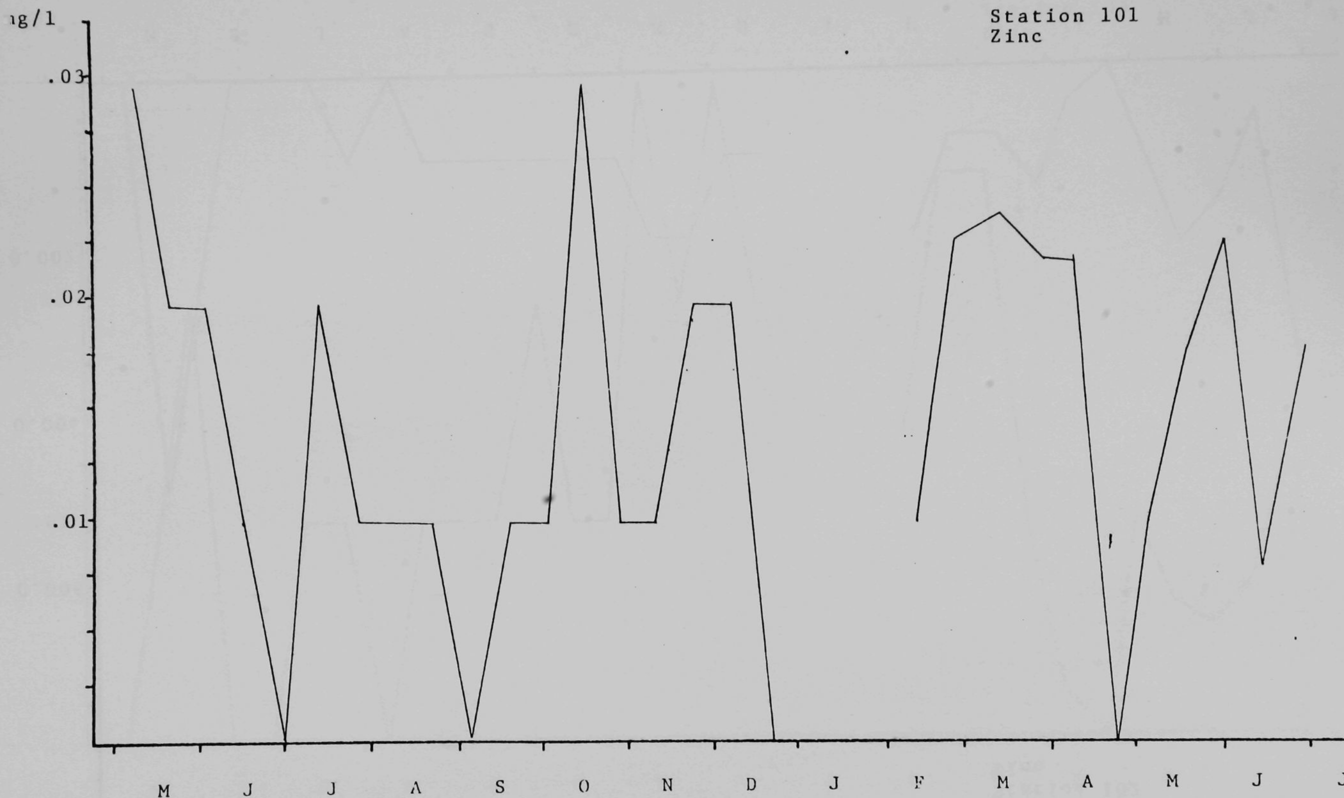


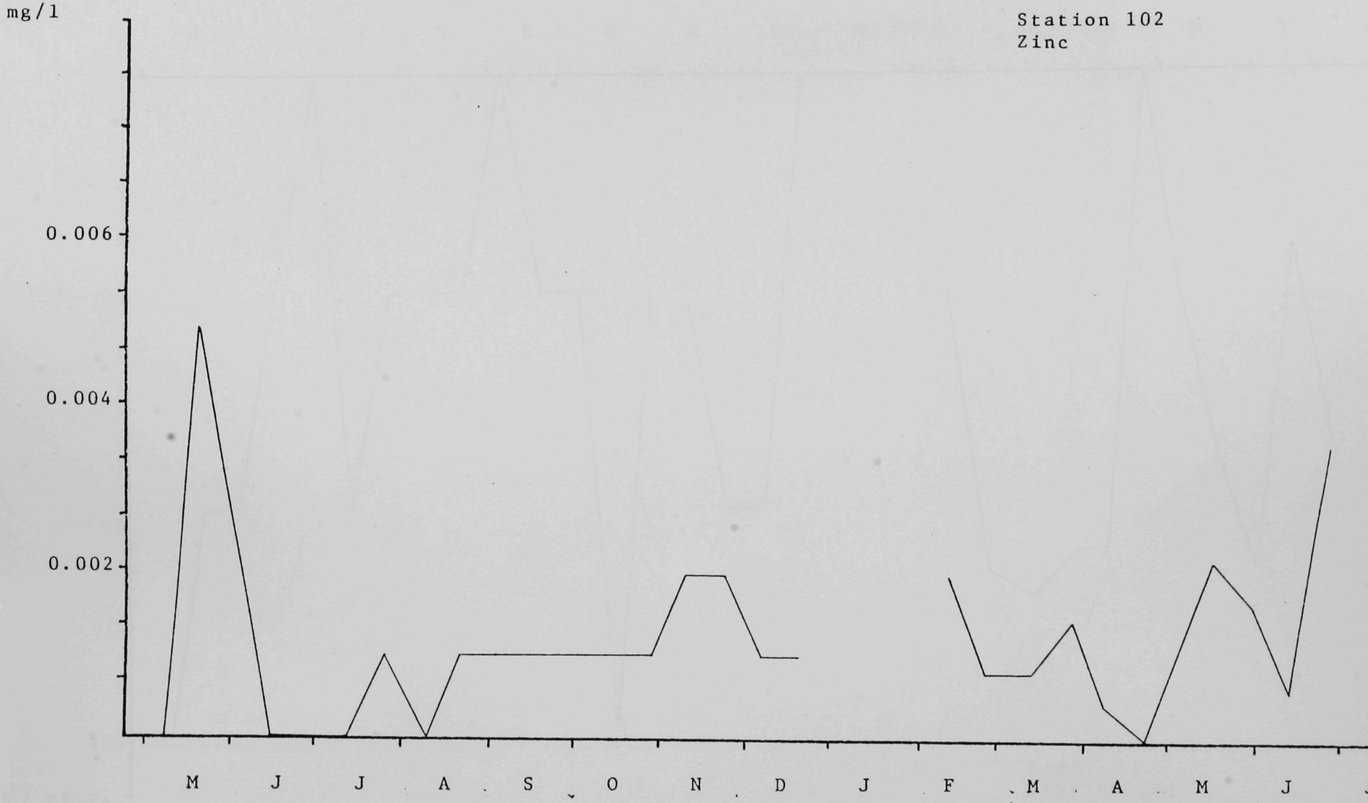

mg/1
.03
.02
.01
Station 106
Copper
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J



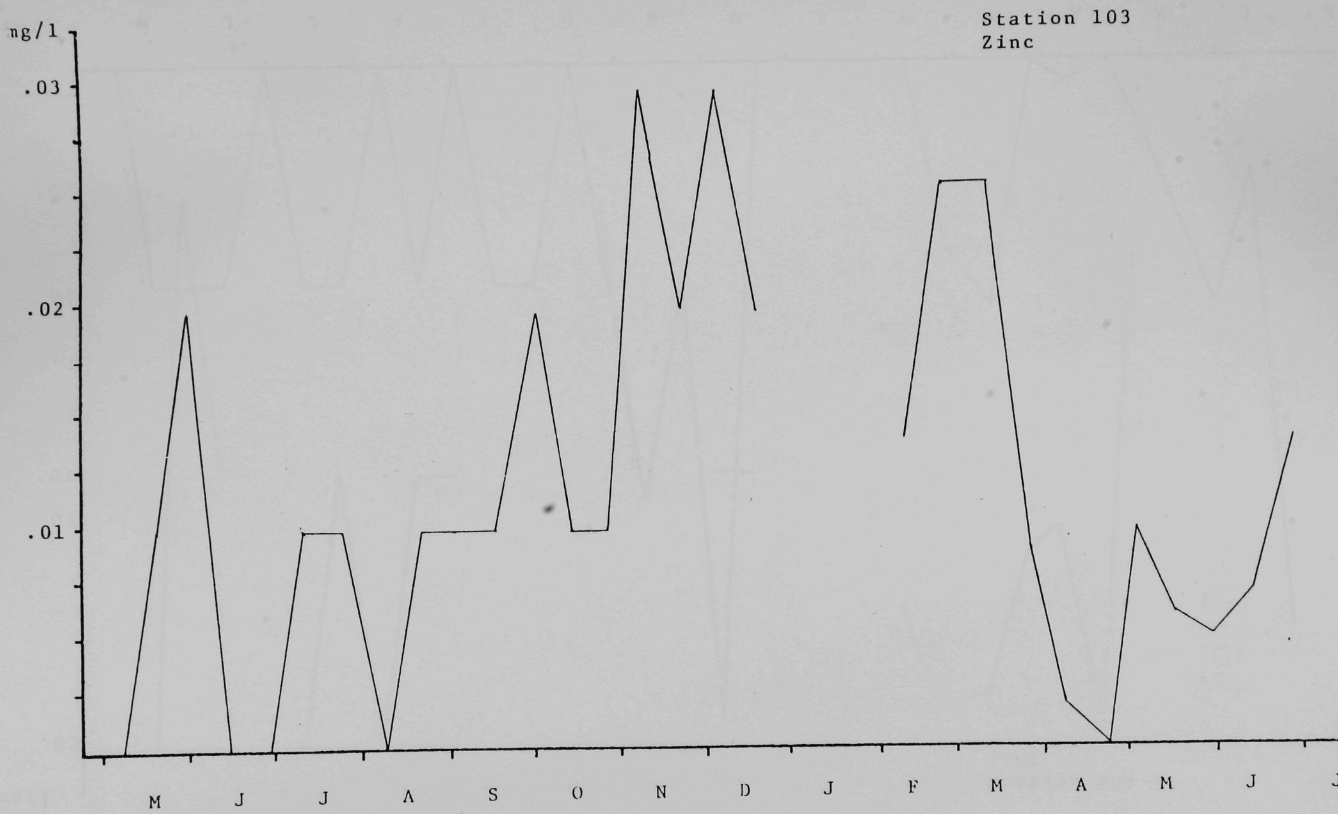
Station 107
Copper
/1
0.06
0.05
0.04
0.03
0.02
0.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


mg/1
Station 108
Copper
0.06
0.05
0.04
0.03
0.02
0.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J

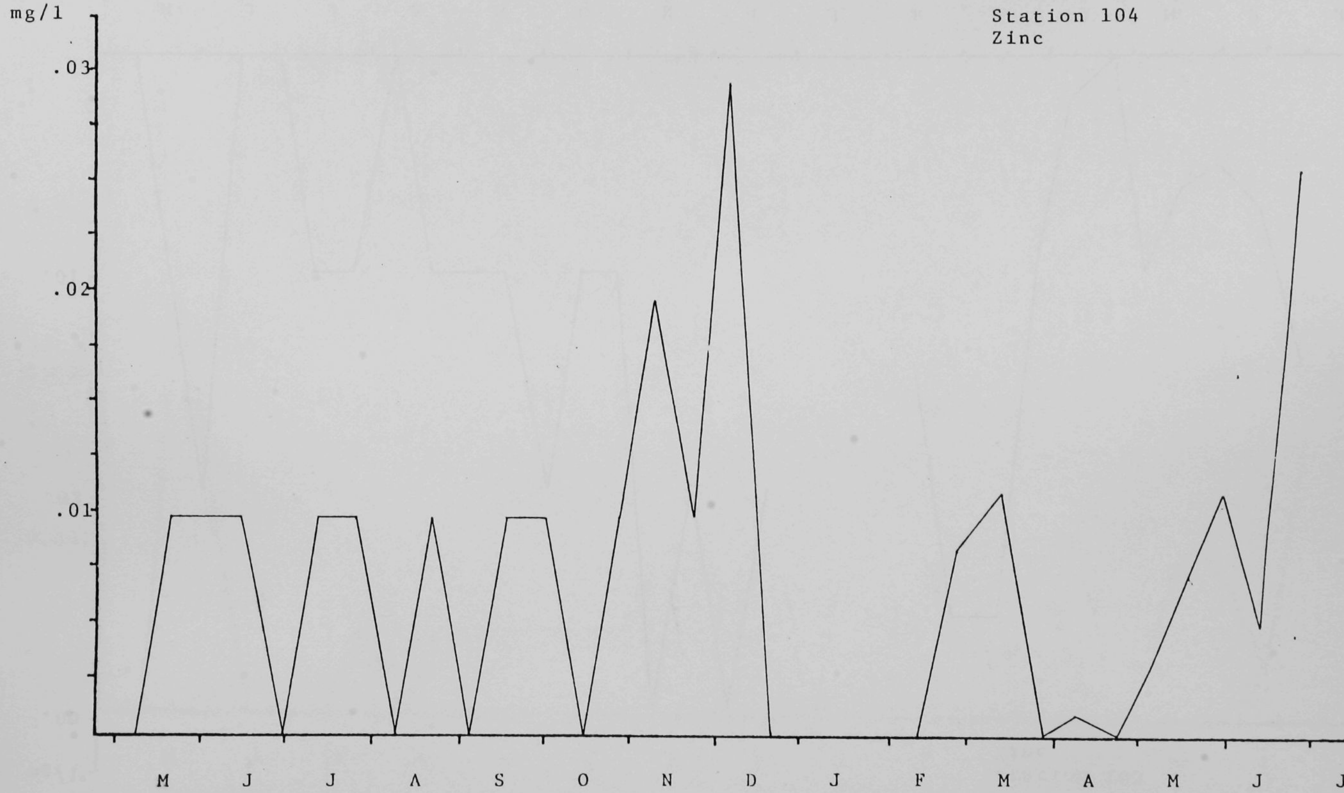

Station 101
Zinc
mg/l
.03
.02
.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

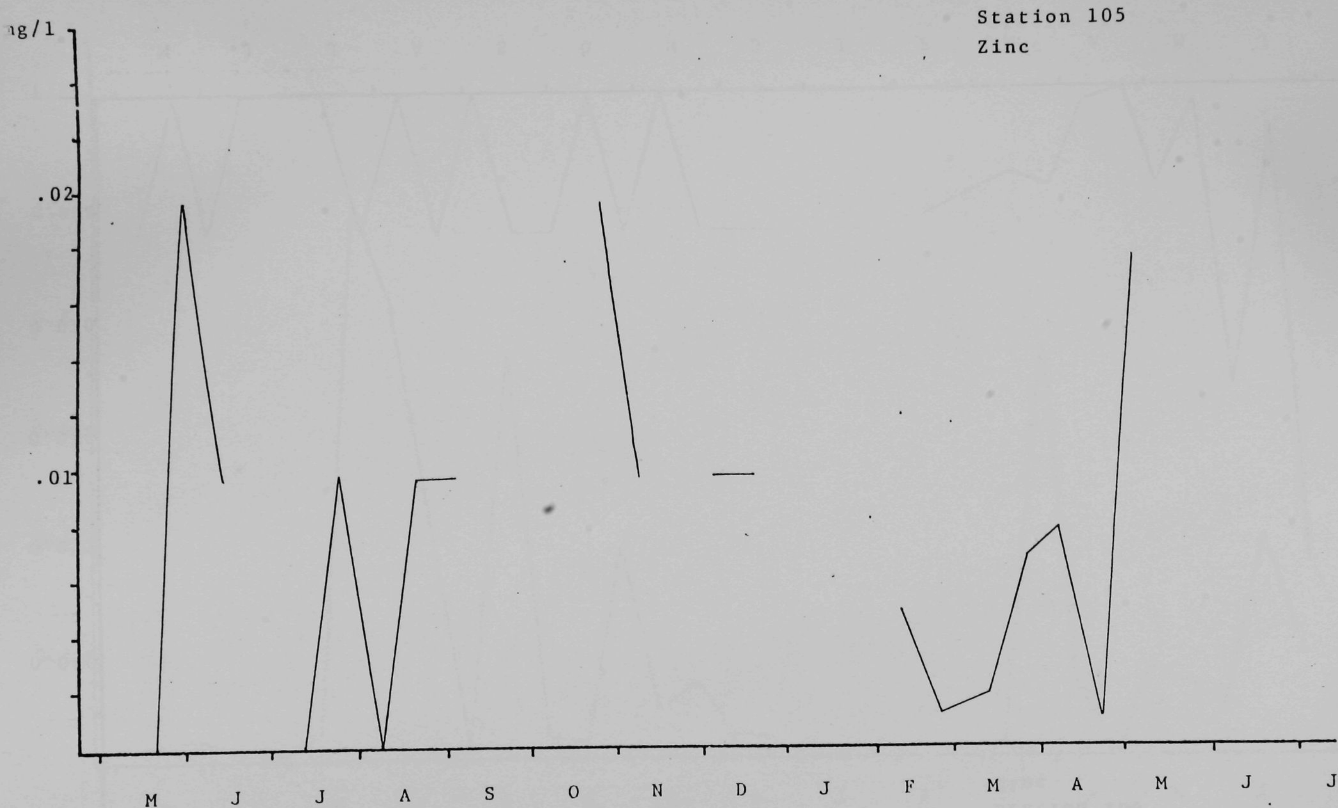


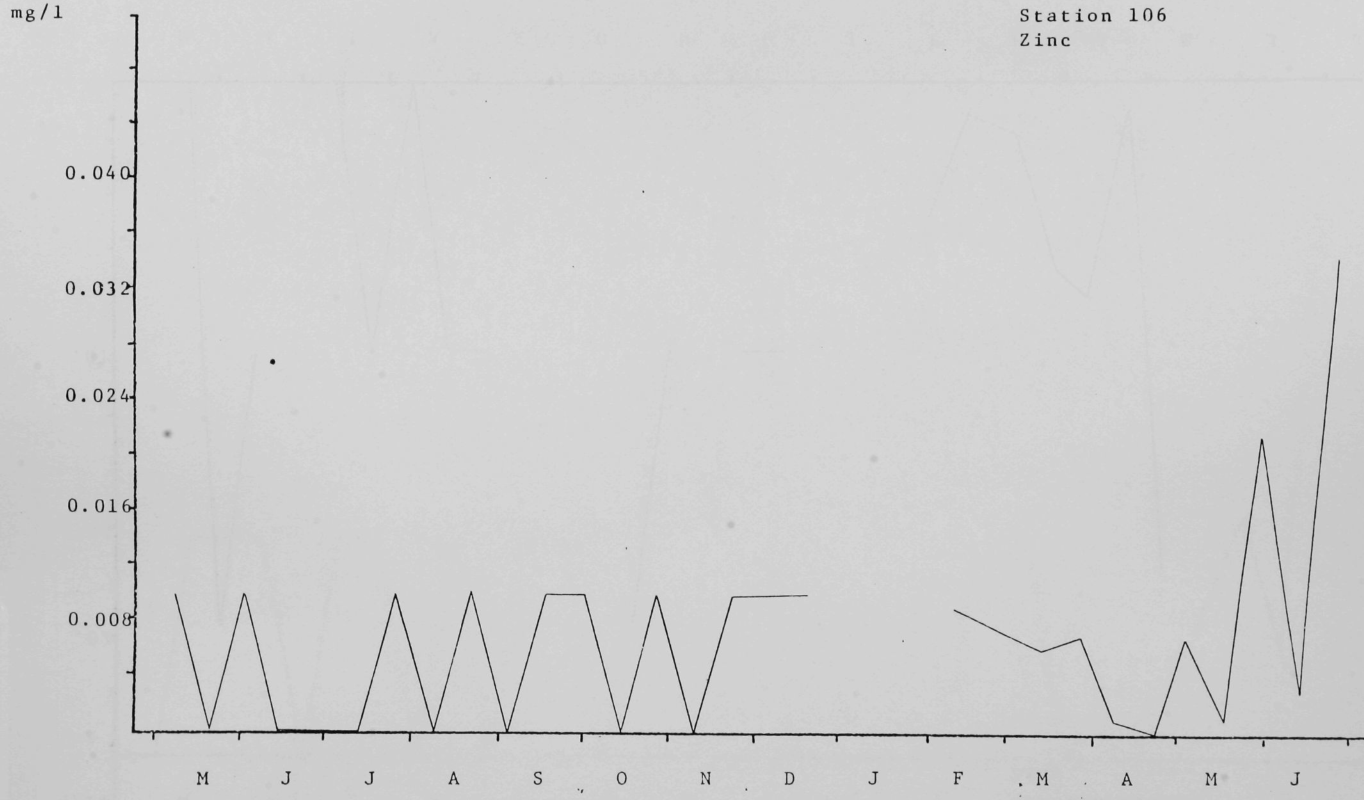
mg/l
Station 102
Zinc
0.006
0.004
0.002
M
J
J
A
S
O
N
D
J
F
M
A
M
J

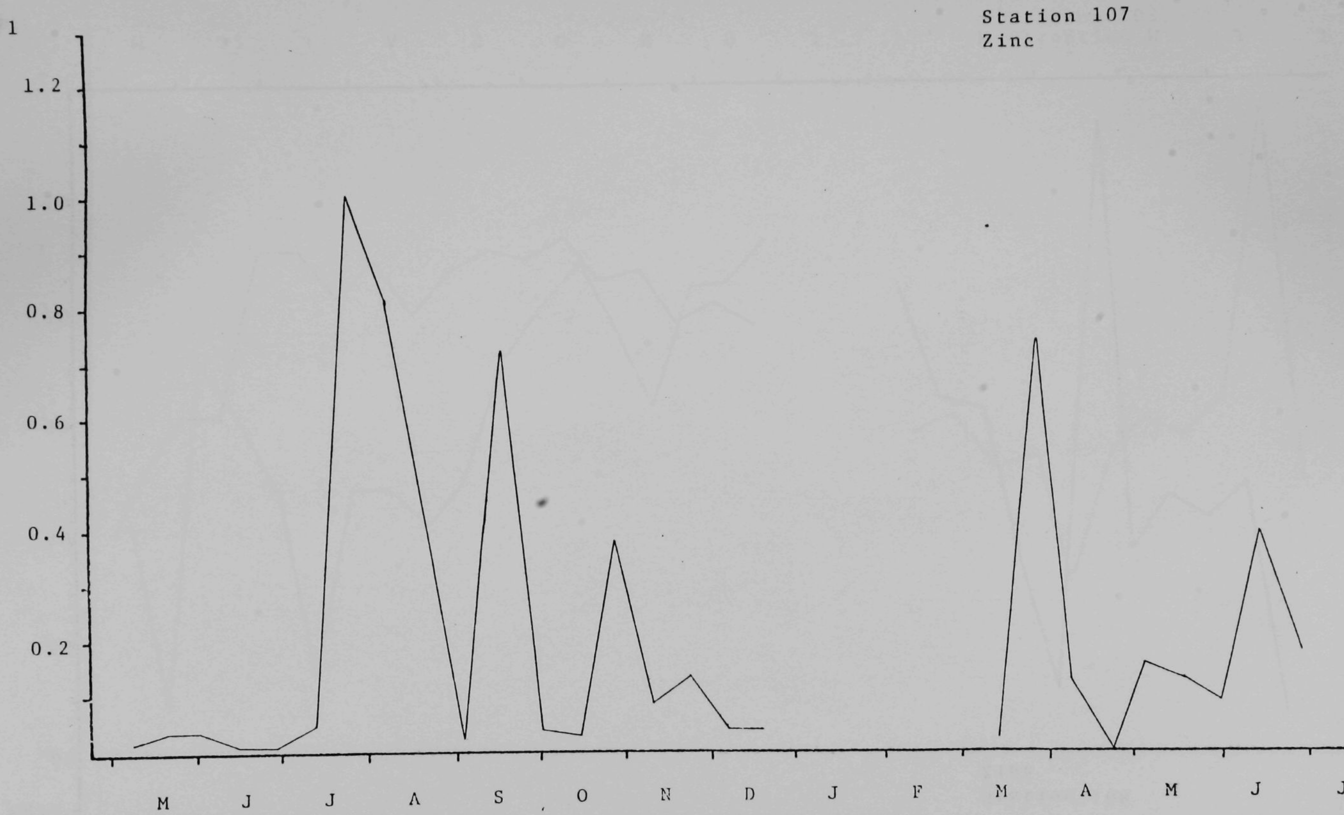


Station 103
Zinc
ng/l
.03
.02
.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


mg/l
Station 104
Zinc
.03
.02
.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 105
Zinc
mg/1
.02
.01
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

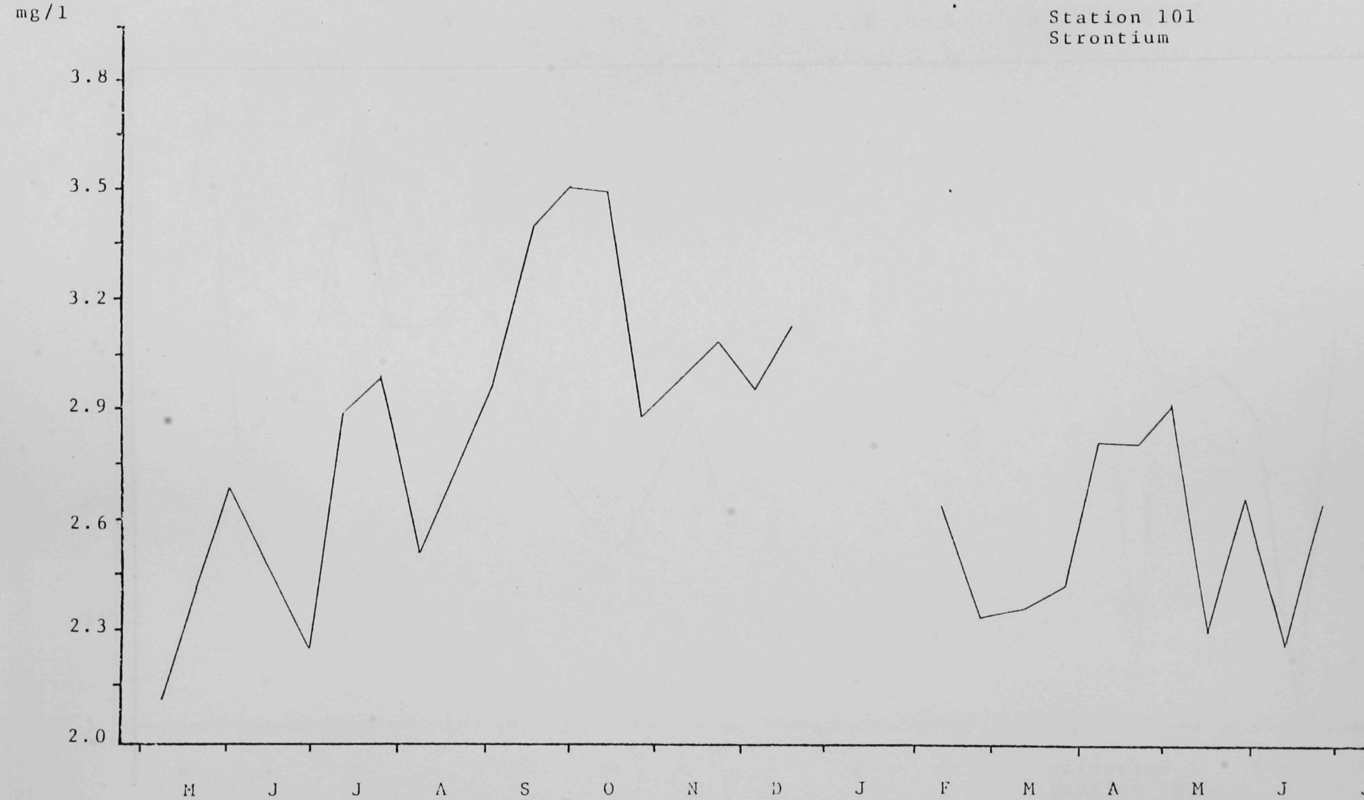

mg/l
Station 106
Zinc
0.040
0.032
0.024
0.016
0.008
M
J
J
A
S
O
N
D
J
F
M
A
M
J


Station 107
Zinc
1
1.2
1.0
0.8
0.6
0.4
0.2
M J J A S O N D J F M A M J J

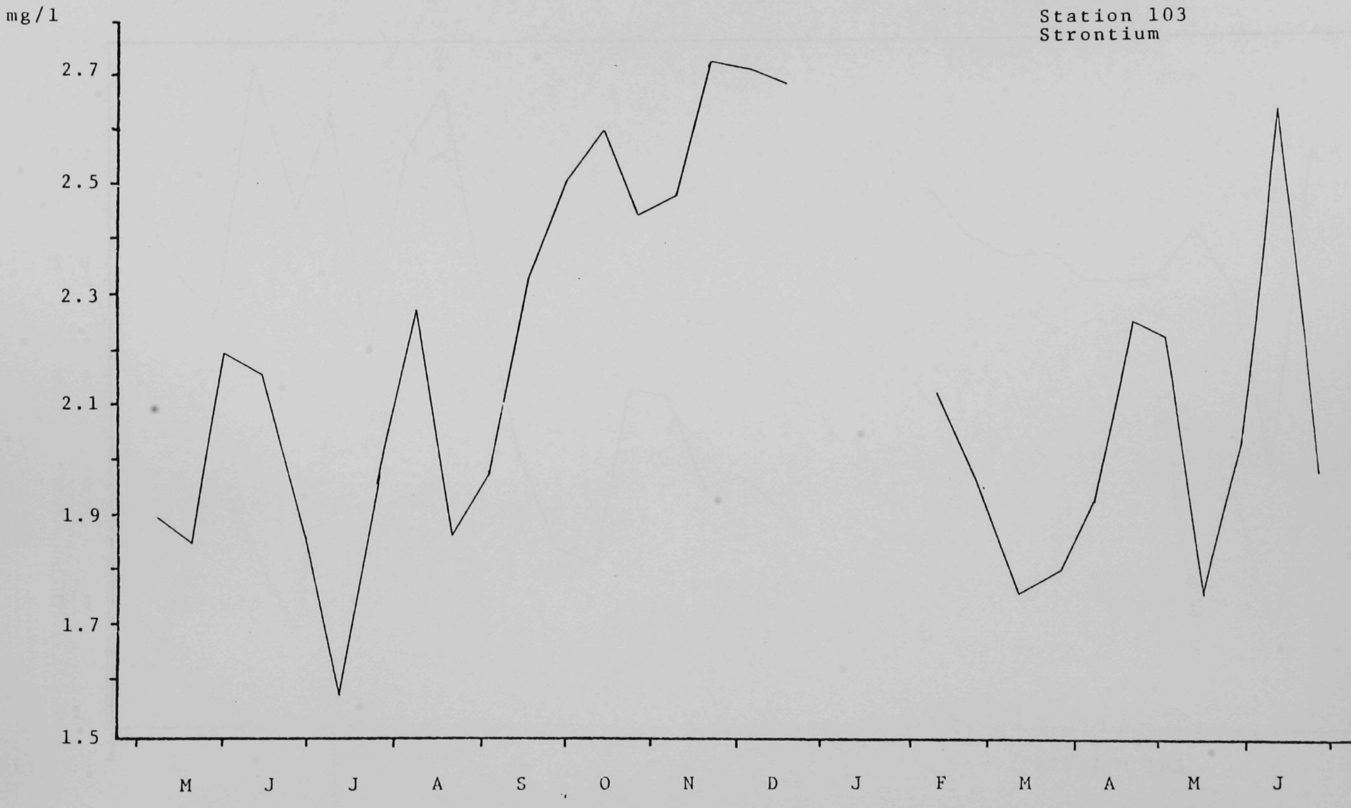

mg/1
.60
.50
.40
.30
.20
.10
Station 108
Zinc
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J

1

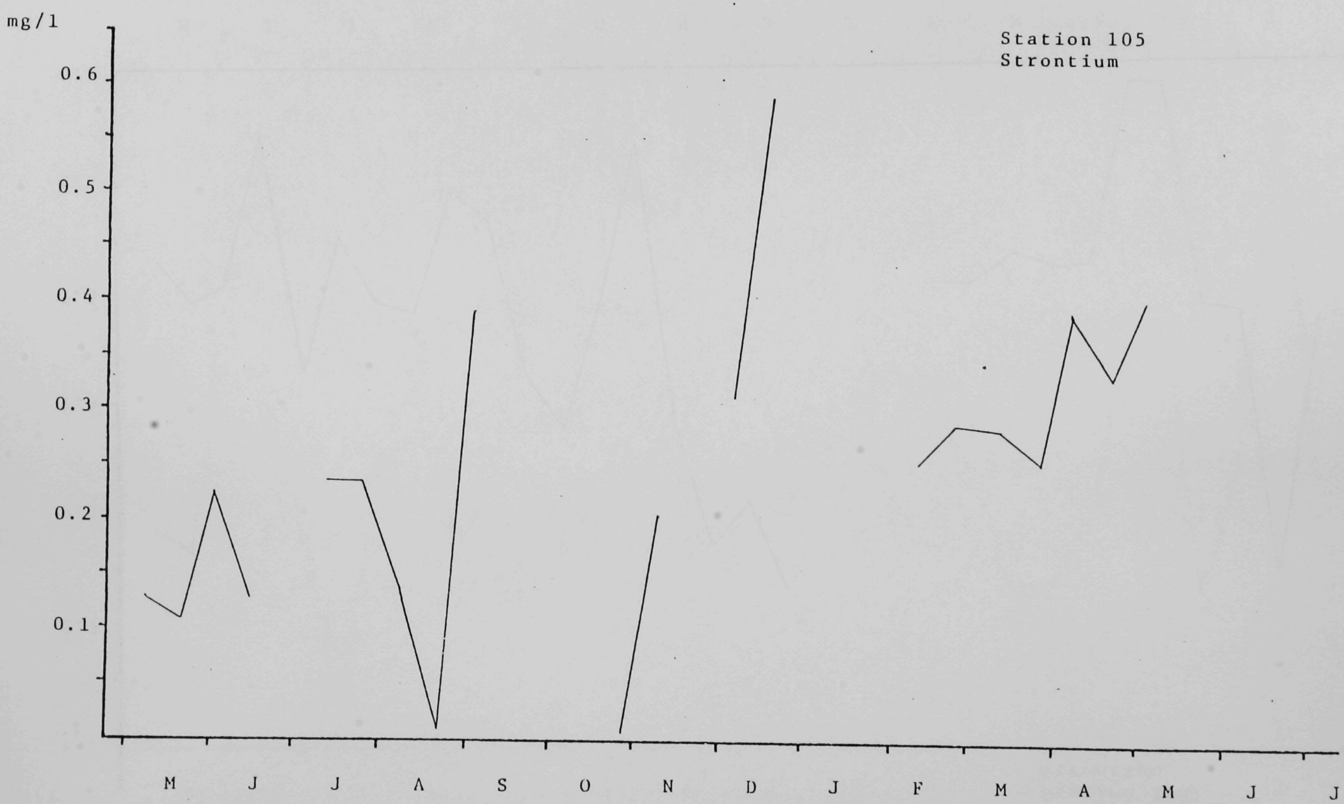
233

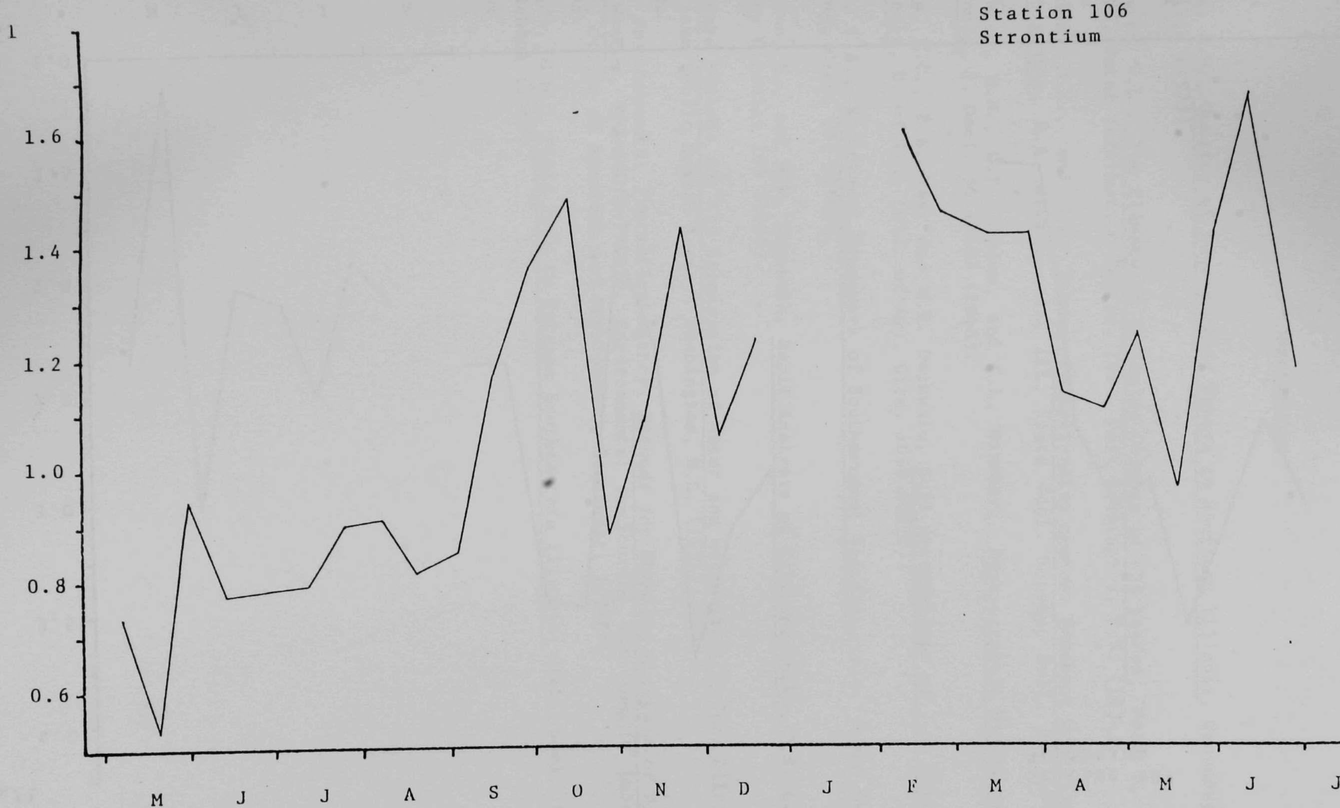

mg/1
Station 101
Strontium
3.8
3.5
3.2
2.9
2.6
2.3
2.0
M
J
J
A
S
O
N
D
J
F
M
A
M
J

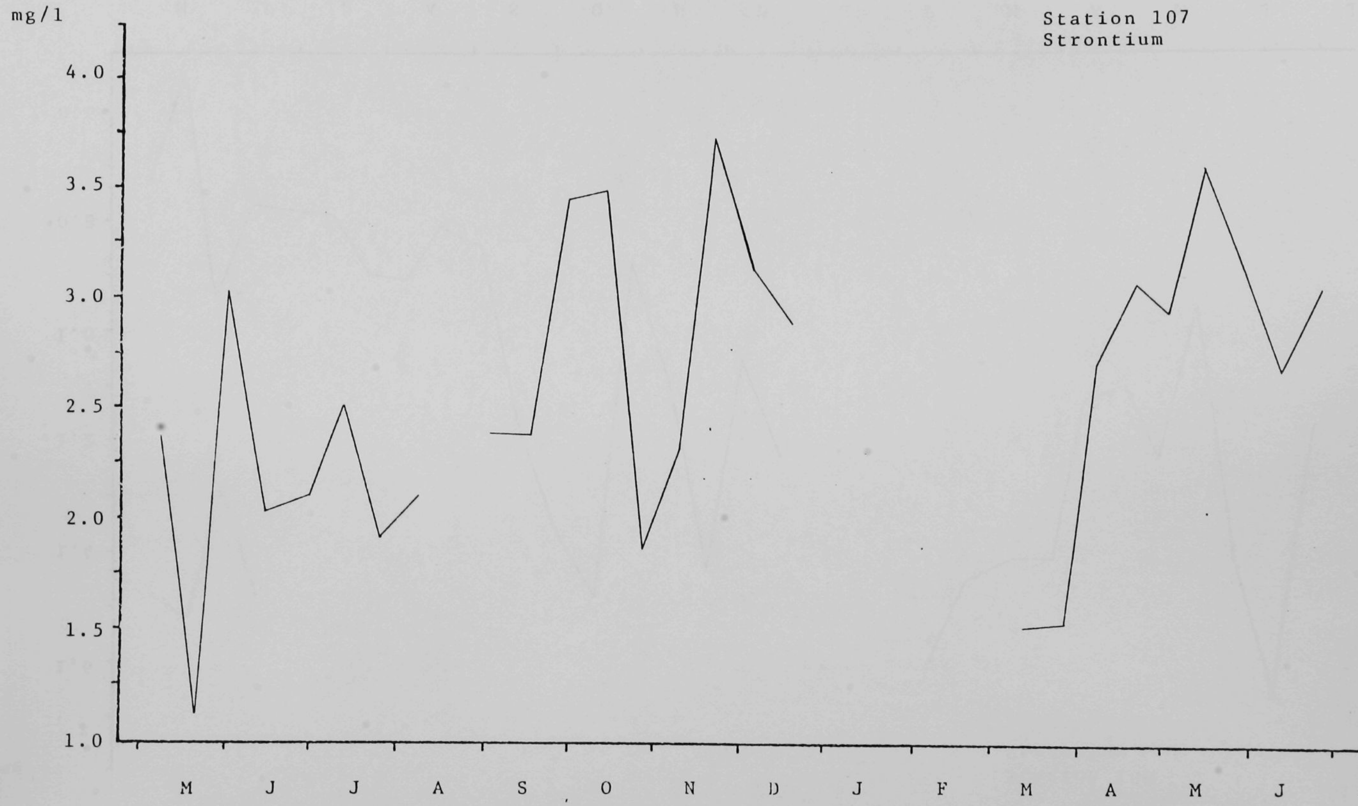

Station 102
Strontium
1
3.2
2.8
2.4
2.0
1.6
1.2
M J J A S O N D J F M A M J J


mg/1
Station 103
Strontium
2.7
2.5
2.3
2.1
1.9
1.7
1.5
M
J
J
A
S
O
N
D
J
F
M
A
M
J

Station 104
Strontium
/1
2.7
2.3
1.9
1.5
1.1
0.7
M J J A S O N D J F M A M J J


mg/l
Station 105
Strontium
0.6
0.5
0.4
0.3
0.2
0.1
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


Station 106
Strontium
1
1.6
1.4
1.2
1.0
0.8
0.6
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J


mg/1
Station 107
Strontium
4.0
3.5
3.0
2.5
2.0
1.5
1.0
M
J
J
A
S
O
N
D
J
F
M
A
M
J

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